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111. Anthony, H.E. The Hall of North American Mammals.
(Reprinted from Natural History, 49:4,1942.)

112. Colbert,E.H. Triumph of the Mammals.
(Reprinted from (Natural History, 49:5, 50:1, 1942.)

113. Curran,C.H. & Lutz,F.E. Insects, Ticks and Human Diseases. 1942.

114. Miner, R.W. Universe Through a Microscope. The Protozoa.
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115. Chapman, F.M. Birds and Man. 1943.

116. Wissler,C. The Archaeologist at Work. 1946.
(Reprinted from Natural History, 51:3,1943)

117. Curran,C.H. Insect Control in the Victory Garden. 1943.

118. Miner, R.W. & others General Guide to...the American Museum of Natural HHistory. 1943.

119. Mackay,W.A. & Canfield,A.S. The Murals in the Theodore Roosevelt Memorial Hall. 1944.

120. Ley,W. Inside the Atom.
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121. Wissler,C. Rice as a World Food.
(Reprinted from Natural History,55:1, 1946.)

122. Gregory,W.K. & Lamont,F. The World of Fishes. 1947.

123. Shapiro,H.L. Peoples of the Pacific.
(Reprinted from Natural History, 53:4, 1944.)

124. Shapiro, H.L. Homes Around the World.
(Reprinted from Natural History, 53:12 & 54:1, 1944-5)

125. Shapiro, H.L. A World full of People. The Facts of Population.
(Reprinted from Natural History, 54: 4, 1945.)

126. Shapiro, H.L. Americans Yesterday, Today, Tomorrow.
(Reprinted from Natural History,54:6, 1945.)

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127. Mayr, E. Birds of Paradise.
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128. Masks and Men. n.d.

129. Wissler,C. The Cereals and Civilization. n.d.

130. Milne,L.J. & Milne, M.J. The Life of the Water Film.
(Reprinted from Natural History, 56:6, 1947.)

131. Shapiro,H.L. From the Neck Up.
(Reprinted from Natural History, 56:10, 1947)

132. Clausen, L.W. The Life History of the Monarch Butterfly. 1948.



THE HALL OF NORTH AMERICAN MAMMALS

By HAROLD E. ANTHONY

THE AMERICAN MUSEUM OF NATURAL HISTORY

Issued under the direction of the
Committee on Popular Publications
Roy W. Miner, *Chairman*



THE NEW HALL OF NORTH AMERICAN MAMMALS BRINGS THE WILDLIFE OF OUR CONTINENT TO NEW YORK CITY

By HAROLD E. ANTHONY

THE AMERICAN MUSEUM OF NATURAL HISTORY

GUIDE LEAFLET SERIES No. 111

Reprinted from Natural History, Volume XLIX, No. 4, April 1942

The American Museum
of
Natural History
PRESENTS

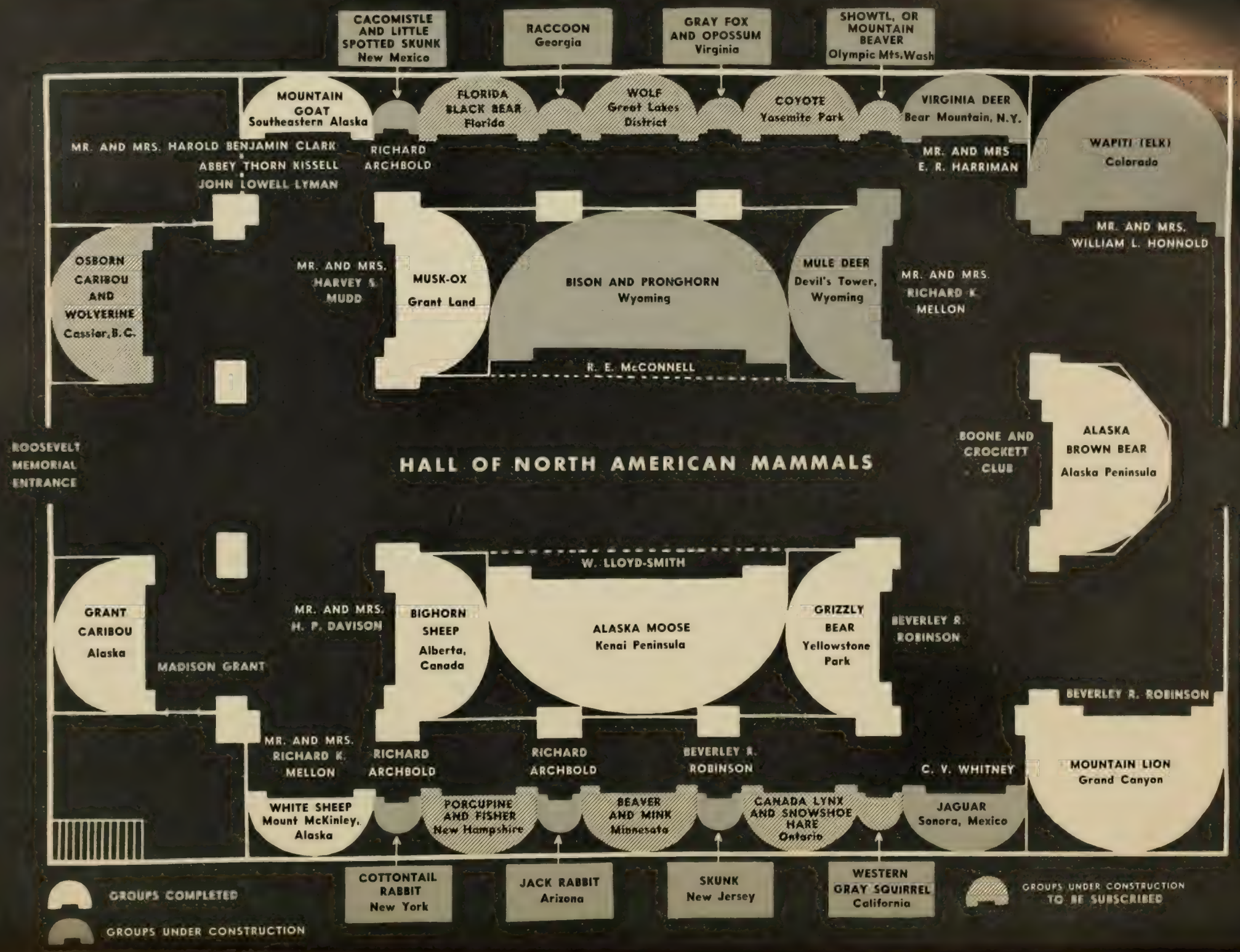
A GRAND

(Below) One of the most difficult animals to see in the wild, the cougar or mountain lion is displayed in the new hall with dramatic realism amid the spacious grandeur of the Grand Canyon

From a Kodachrome by Thane Bierwert



With the generous support and able cooperation of the many individuals whose names appear on these pages the fine exhibits in this new Hall have been made possible.


CACOMISTLE AND LITTLE SPOTTED SKUNK New Mexico
RACCOON Georgia
GRAY FOX AND OPOSSUM Virginia
SHOWTL, OR MOUNTAIN BEAVER Olympic Mts, Wash
MOUNTAIN GOAT Southeastern Alaska
FLORIDA BLACK BEAR Florida
WOLF Great Lakes District
COYOTE Yosemite Park
VIRGINIA DEER Bear Mountain, N.Y.
MR. AND MRS. HAROLD BENJAMIN CLARK
ABBEY THORN KISSELL
JOHN LOWELL LYMAN
RICHARD ARCHBOLD
MR. AND MRS E. R. HARRIMAN
WAPITI (ELK) Colorado
MR. AND MRS. WILLIAM L. HONNOLD
OSBORN CARIBOU AND WOLVERINE Cassiar, B.C.
MR. AND MRS. HARVEY S. MUDD
MUSK-OX Grant Land
BISON AND PRONGHORN Wyoming
MULE DEER Devil's Tower, Wyoming
MR. AND MRS. RICHARD K. MELLON
R. E. McCONNELL
ROOSEVELT MEMORIAL ENTRANCE
HALL OF NORTH AMERICAN MAMMALS
BOONE AND CROCKETT CLUB
ALASKA BROWN BEAR Alaska Peninsula
W. LLOYD-SMITH
GRANT CARIBOU Alaska
MADISON GRANT
MR. AND MRS. H. P. DAVISON
BIGHORN SHEEP Alberta, Canada
ALASKA MOOSE Kenai Peninsula
GRIZZLY BEAR Yellowstone Park
BEVERLEY R. ROBINSON
BEVERLEY R. ROBINSON
MR. AND MRS. RICHARD K. MELLON
RICHARD ARCHBOLD
RICHARD ARCHBOLD
BEVERLEY R. ROBINSON
C. V. WHITNEY
MOUNTAIN LION Grand Canyon
WHITE SHEEP Mount McKinley, Alaska
PORCUPINE AND FISHER New Hampshire
BEAVER AND MINK Minnesota
CANADA LYNX AND SNOWSHOE HARE Ontario
JAGUAR Sonora, Mexico
COTTONTAIL RABBIT New York
JACK RABBIT Arizona
SKUNK New Jersey
WESTERN GRAY SQUIRREL California
GROUPS COMPLETED
GROUPS UNDER CONSTRUCTION
GROUPS UNDER CONSTRUCTION TO BE SUBSCRIBED

DONORS OF GROUPS IN HALL OF NORTH AMERICAN MAMMALS

The names of those who have donated groups to the Hall of North American Mammals are listed below as well as on the floor plan opposite where they appear next to the groups donated.

MR. RICHARD ARCHBOLD
Cacomistle and Little Spotted Skunk Group
Cottontail Rabbit Group
Jack Rabbit Group

BOONE and CROCKETT CLUB
Alaska Brown Bear Group

MR. and MRS. HAROLD BENJAMIN CLARK
Mountain Goat Group

MR. and MRS. H. P. DAVISON
Bighorn Sheep Group

MR. MADISON GRANT
Grant Caribou Group

MR. and MRS. E. R. HARRIMAN
Virginia Deer Group

MR. and MRS. WILLIAM L. HONNOLD
Wapiti Group

MISS ABBEY THORN KISSELL
Mountain Goat Group

MR. WILTON LLOYD-SMITH
Alaska Moose Group

MR. JOHN LOWELL LYMAN
Mountain Goat Group

MR. and MRS. R. E. McCONNELL
Bison and Pronghorn Group

MR. and MRS. RICHARD K. MELLON
White Sheep Group
Mule Deer Group

MR. and MRS. HARVEY S. MUDD
Musk-ox Group

MR. BEVERLEY R. ROBINSON
Grizzly Bear Group
Mountain Lion Group
Skunk Group

MR. C. V. WHITNEY
Jaguar Group

In addition to the groups donated, contributions have been received for the development of the wall treatment in the hall and for various expenditures not to be classified as costs of individual exhibits.

Credit should also be given to Colonel Francis T. Colby who collected specimens and accessories for the Alaska Brown Bear Group; to Mr. Wilton Lloyd-Smith for collecting specimens and accessories for the Grant Caribou Group; and to Dr. Henry M. Beck who donated the world's record horns for the Bighorn Sheep Group.

The floor plan shows the hall with the construction as it existed on Members Day, April 8, 1942.

SPECIAL ADVISORY COMMITTEE HALL OF NORTH AMERICAN MAMMALS

ROBERT EARLL McCONNELL, *Chairman*

CHILDS FRICK
DOUGLAS BURDEN
BEVERLEY R. ROBINSON
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H. B. CLARK
RICHARD K. MELLON
HAROLD E. ANTHONY
JAMES L. CLARK

THE HALL OF NORTH AMERICAN MAMMALS

This panoramic exhibit of the animals of our continent in their natural settings embodies the latest and most progressive principles in scientific display.

Beginning some 30 years ago, a new ideal was envisioned in museum exhibiting. This ideal aspired to achieve new educational purposes through the realistic portrayal of wildlife in scenes of artistic beauty. Its realization depended upon the development of an elaborate new technique, and its watchwords have been truth, beauty, and faith in the value of Nature's lessons to man.

Many of the artists who helped to develop the method have also contributed their talents to the creation of this hall, which is thus a monument to their collective efforts and a climax in the evolution of a unique art. In admiration of its present and future implications, The American Museum extends sincere tribute to their names.

ART AND TECHNICAL DIRECTION

James L. Clark

Albert E. Butler

SCIENTIFIC DIRECTION

Harold E. Anthony

ON THE PAINTING OF BACKGROUNDS

JAMES PERRY WILSON	Grizzly Bear Bison and Pronghorn Wapiti (Elk) Jaguar
FRANCIS LEE JAQUES	Musk-ox
BELLMORE BROWNE	Alaska Brown Bear
GEORGE BROWNE assisting	White Sheep Bighorn Sheep Grant Caribou Osborn Caribou
CHARLES S. CHAPMAN	Mountain Lion
CARL RUNGIUS	Alaska Moose
JOSEPH M. GUERRY	Mountain Goat
FRED SCHERER	Virginia Deer Assisting on Bison and Pronghorn

ON THE MOUNTING OF ANIMALS

ROBERT H. ROCKWELL	Alaska Moose White Sheep Bighorn Sheep Grant Caribou Wapiti (Elk) Bison and Pronghorn Osborn Caribou Musk-ox Alaska Brown Bear
GARDELL D. CHRISTENSEN	Mountain Goat Grizzly Bear Virginia Deer Osborn Caribou Mountain Lion
GEORGE ADAMS	Mountain Lion Jack Rabbit Jaguar

ON THE BUILDING OF THE FOREGROUNDS

GEORGE E. PETERSEN	Wapiti (Elk) Grizzly Bear
G. FREDERICK MASON	White Sheep Mountain Lion Alaska Moose Musk-ox Alaska Brown Bear Wapiti (Elk) Grant Caribou Osborn Caribou Bison and Pronghorn Bighorn Sheep
JOSEPH M. GUERRY	Mountain Goat Alaska Brown Bear Bighorn Sheep
PAUL M. WRIGHT	Jaguar Bighorn Sheep
CHARLES B. TORNELL	Bison and Pronghorn Wapiti (Elk) Bighorn Sheep
BERNARD F. CHAPMAN	Grizzly Bear
RAYMOND H. DELUCIA	Mountain Lion Grizzly Bear Bighorn Sheep Jaguar
JAMES CARMEL	Alaska Moose

Since the realistic effect of these displays depends to a great extent on special techniques in illumination, particular credit is due the Museum's departments of Construction and Lighting.

TOUR OF NORTH AMERICA

As on a magic carpet, the city-dweller can view the wildlife of our continent from Mexico to the Arctic in the new Hall of North American Mammals

By HAROLD E. ANTHONY

Curator, Department of Mammals
The American Museum of Natural History

THE splendid animals that are native to our continent, the scenic wonders that form their natural background in the wild, and the valuable lessons that can be learned from Nature, particularly in the conservation of our national resources —all these make the new Hall of North American Mammals a most important addition to the world-embracing exhibits in the American Museum of Natural History.

A hall depicting the life of our own continent had long been needed. In comparison with the modern halls devoted to African and Asiatic wildlife, our exhibits on North America were shabby and inadequate. The interest in our own North American fauna demanded that we do as well by the natives as by the aliens. The plan was set in motion, and eighteen separate expeditions, ranging from Mexico to Ellesmere Land north of Baffin Island and from the Atlantic Coast to the Pacific, have contributed to its realization.*

Embracing the expanse of North America thus covered, the new hall will bring to New York an impressive series of vistas into the best of primeval North America. Each animal group is an attempt to portray one or more species of mammal in an outstanding scene from the great outdoors. Many of these settings, such as Yellowstone Park, are favorite places of the tourist—regions selected by the government as National Parks because of their unique scenic and environmental values. Others are off the well-traveled routes. Mountain, desert, and arctic tundra, woodland and prairie—all types of geographic environment are represented in this comprehensive series of exhibits.

The selection of animals to go into the Hall has called for the most careful consideration. Animals having the greatest interest to the largest number of visitors have been given the most important positions. The hall has 29 alcoves, some of them very large. While the list of mammals in North America is a long one and no hall could show them all, even the lesser animals are properly represented in the smaller display groups. Whereas Akeley African Hall has a main hall and a balcony to devote to its exhibits, North American Hall achieves a practically equivalent display on one floor, as will be noted on the sketch plan of the groups.

This new hall is more than a hall of North American mammals. It is a hall of North American geography in a broad sense, a hall of North American ecology, with botany and all of the other environmental factors receiving the utmost attention. In planning the Mountain Lion Group, for example, the setting had to be one where this large cat was perfectly at home, a place where he belonged. The locality selected is the Grand Canyon. The lions themselves in the group are the obvious center of interest for the visitor; but they are only a single element out of many contained in the display. Beyond the lions, as far as the eye can see, stretches the breath-taking grandeur of the Grand Canyon, with the San Francisco Mountains in the distance, a spectacle unmatched anywhere in the world. It has been truthfully stated that no painting can do justice to the Grand Canyon. But a person in New York cannot see the Canyon itself, and this group is by all odds the next-best thing to being on the North Rim in person.

The casual visitor views the background in terms of enjoyment and entertainment, but a geologist sees in it a marvelous example of stratigraphy and of erosion on a stupendous scale. A student of botany or ecology—the science of plants, animals, and environment in their relation to each other—sees other things. He sees the flower known as the cliff rose growing out of the rock in the foreground, the cactus near at hand, the arid aspects of the landscape, and

* Credit for the new Hall of North American Mammals is shared by several organizations and many individuals. Without the financial support given by the City of New York and the interested co-operation of the Mayor, the Comptroller, and of the Commissioner of Parks, the American Museum would not have had the building and the physical equipment for the hall. A special advisory committee for the hall has been in existence since the plans were in the blueprint stage. The late Madison Grant was chairman of this body for some years. Since active construction was begun the committee has been as follows:

ROBERT EARLL MCCONNELL, Chairman
CHILDS FRICK
DOUGLAS BURDEN
BEVERLEY R. ROBINSON
E. ROLAND HARRIMAN
H. P. DAVISON
MALCOLM P. ALDRICH
H. B. CLARK
RICHARD K. MELLON
HAROLD E. ANTHONY
JAMES L. CLARK

the lack of any vegetation on many of the slopes, demonstrating that erosion of the land proceeds unabated when there is no ground cover to check it.

The new Hall of North American Mammals should appeal to all classes of visitors. To many the exhibits will be entertainment, which is certainly an important criterion for Museum exhibition. It is especially important during this period of world-wide turmoil, when the daily press and the radio continually impress one with man's destructive powers and when there are so few releases from the war psychology. Even in a war-mad world, the outdoor man knows that, at such times as he can escape the sphere of man's domination, he will find the sun still shining, the plants and trees still green or budded with promise, and the animal life still pursuing the same pattern of life as during times of peace. The finer things of Nature are immutable, and man will be the better for it if he can divest himself of his own interferences with the universe and get back to first principles. The habitat groups of North American mammals will offer a valuable refuge and an opportunity for eyes weary of city streets to enjoy a grand tour of the North American continent. For a while at least, the visitor can lose himself in communion with Nature. He will not find it difficult to forget the barriers of glass and wood. The life-like animals are poised for action, and the illusion is so successful that one has the impression of observing living animals in their natural homeland, at closer range than is often offered the naturalist in the field.

Children will see for the first time many of the animals of our continent. They will learn the simpler facts in the life history of the animals from visual observation of the group and from the accompanying label. Many of the scenic backgrounds would remain an unknown world to them, unless they came to the Museum. Adults in search of education will get more from the groups in measure as their individual backgrounds afford the basis for interpretation, and in the direction their curiosity leads them. The sportsman needs little beyond the immediate visual stimulation to grasp the meaning of an exhibit showing an animal he has hunted.

For many visitors, the educational value of a museum is more effective if it is not too obvious and if it is sugar-coated. If exhibits are openly displayed as lessons, many visitors will turn aside because they are not in the mood. But even the individual frankly in search of entertainment is educated unconsciously if the exhibit is planned along the proper lines. Students or classes using the Museum for source material will find that the new hall offers great opportunities.

A great deal of special information can be given in guide leaflets. It is impossible to set forth on a label all the facts covering one of these habitat groups. Labels must be restricted to a size and prominence that will not compete with the group itself and act as a distracting influence in the hall. The beauty and the illusion of reality are lost if large, conspicuous labels catch the eye at every turn. They are like brilliant signboards in the wilderness, and few would come to a museum on the primary appeal of labels. But the visitor can keep the guide leaflet to read at his leisure, if he does not care to do so at the side of the group while he is in the Museum. An outline or a syllabus will probably best serve the class in nature study, in ecology, or in geology. Such an outline would point out the salient facts as demonstrated in each group. It might suggest the best order in which to study the groups and refer to supplementary information that can be derived from other halls in the Museum and from collateral reading. The education and inspiration are there for those who seek them, for in these exhibits the visitor "Finds tongues in trees, books in the running brooks, sermons in stones."

The sex and age of the animals making up a group, as well as the posing of them, must be carefully planned in advance. A popular idea is to show male, female, and young, thus stressing the family associations. An invariable adherence to this pattern, however, would become monotonous and would prevent the display of much more interesting attributes. For example, male deer are most impressive in the fall of the year when their antlers are at their prime. At this season the young, on the other hand, are no longer tiny, spotted creatures; hence a fall group of buck, doe, and spotted fawn would be a biological misfit. This illustrates in a simple way a multitude of considerations, which extend to include flowers and other seasonal vegetation in an authentic group. Or again, among mountain sheep the rams with their massive horns are so much more eye-arresting than the ewes that they draw the limelight on any stage they occupy. Furthermore, during a large part of the year the big rams range in small groups apart from the ewes, so that it is good natural history plus good showmanship to plan a sheep group with the rams monopolizing the attention. Mountain sheep live in precipitous rugged topography, and as a foil against the mighty mountain background the powerful and majestic rams get first call on the foreground. The composition of the various groups can be studied, along with the explanations accompanying them, in the pictorial section following this article.

Work is far advanced on five other large groups, and a beginning has been made on still others. Since the construction of such a large hall is an operation

requiring years, the committee in charge decided to open it in advance in order to get the maximum use of the results. This will also enable visitors to see something of the groups under construction. To most people the actual creation of a group—the painting of the background, the assembling of the accessory material, the composing of the group itself—are matters of great interest. And the appreciation of the end product is increased if one has noted the careful and laborious steps by which it has been achieved.

None of the smaller groups have been completed, but these will round out the full picture of the animal life of our continent. And let no one think that because they are small they are of minor consequence. With the larger mammals, which are the game animals, the time of the year must invariably be fall, winter, or early spring. At any other time than the period of cold weather the pelage will be shabby or antlers will be unprime or missing completely. In the case of the smaller mammals these factors are not disturbing, and one can select a season when Nature has furnished a more gracious environment. Whereas a large mammal like the bison wears a worn or shedding coat in early summer, a skunk or a jack rabbit makes an altogether satisfactory exhibit at that season. Consequently, the smaller groups can go around the calendar and will provide the hall with spring and summer barkgrounds.

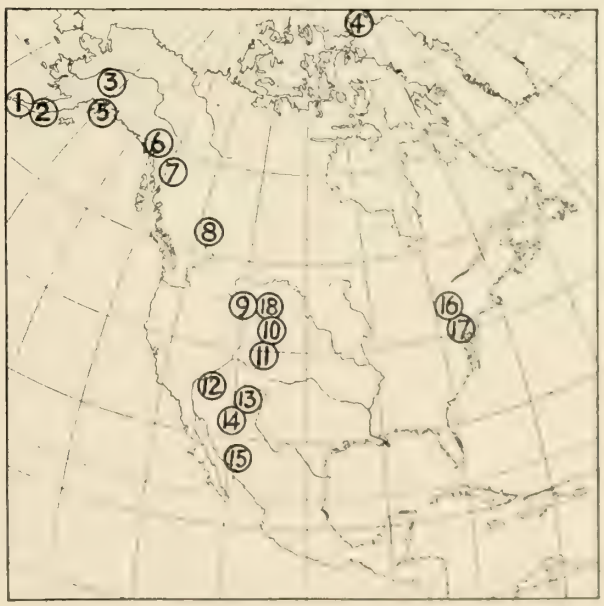
The average person who is familiar with the North American mammals of today does not realize the great variety of animal life from which they are survivors. Many mammals which now exist only in the eastern hemisphere had representatives in North or South America some thousands of years ago in the Pleistocene, or Ice Age. Sportsmen who marvel at the great variety of animals living in Africa today are interested to learn that our North American fauna of geologic yesterday was equally extensive and that many species have been lost with the advent of the Recent epoch. To give a brief survey of the predecessors of our existing North American mammal fauna, it is planned to have introductory exhibits at the entrance to North American Hall. These exhibits will show a few of the absentee mammals and give the visitor a better insight into the fauna of our continent.

Other features of the hall which are planned but which will not be evident at the opening are the charts, maps, and diagrams which will be placed upon such of the walls as permit. These two-dimensional exhibits will cover a multitude of subjects having a direct bearing upon the distribution, evolution, and significance of the mammals on display. No class of animals can be discussed in the fullest terms if held apart from such fundamental factors as vegetation, climate, and topography. To understand the causes which make mammals look and act as they do, one must know something of their environment and of the forces which work upon all living matter. Many of the casual relations in this complex problem are yet to be discovered or formulated, but there are many factors which by association appear to have profound effects. Information of the latter character, such as distribution of forests, rainfall, desert, etc., will be given in chart form in some of these wall exhibits. The evolution of special structures or adaptations, such as the development of antlers through the life history of an animal, will also lend themselves to graphic display; and the rate of increase or decrease of various animals will illustrate many principles closely connected with the conservation of wildlife.

The pages following this article will show the reader something of the wide variety of informative and artistic material which makes the hall of North American mammals the foremost exhibit of its kind in the world.

The work of eighteen expeditions is embodied in the displays in the new hall, and others will follow.

1. ALASKA BROWN BEAR
2. GRANT CARIBOU
3. WHITE SHEEP
4. MUSK-OX
5. MOOSE
6. MOUNTAIN GOAT
7. OSBORN CARIBOU
8. BIGHORN SHEEP
9. GRIZZLY BEAR
10. MULE DEER
11. WAPITI (ELK)
12. MOUNTAIN LION
13. CACOMISTLE & SPOTTED SKUNK
14. JACK RABBIT
15. JAGUAR
16. COTTONTAIL RABBIT
17. VIRGINIA DEER
18. BISON & PRONGHORN





Alaska Brown Bear

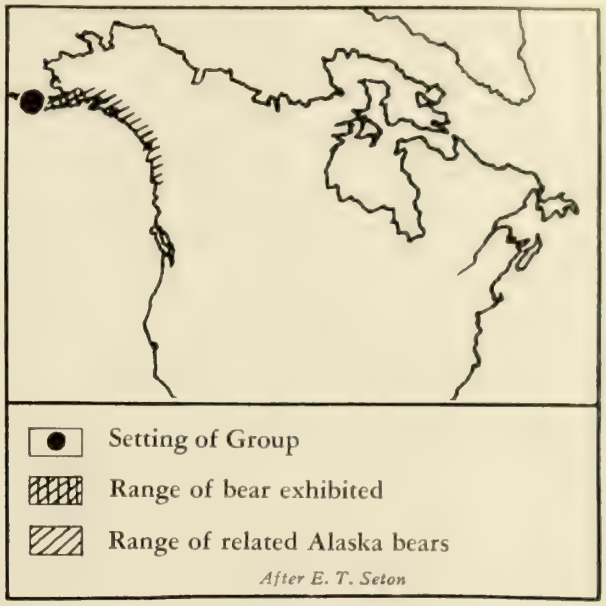
Ursus gyas Merriam

THIS huge bear is the first figure you will see upon entering the new Hall of North American Mammals. Its gigantic form, viewed against a background of towering Alaskan peaks, staggers the imagination. The Alaska Brown Bear sometimes weighs over 1600 pounds and is the world's largest carnivore. In ferocity, however, it does not have the reputation of the grizzly. Its great size is probably related to its abundant food supply. Hoards of salmon *(foreground, below)* run all summer, and the plentiful vegetable food of late spring and late fall is supplemented by mice, marmots, and carrion.

The brown bear goes into hibernation high on mountain slopes, sometimes as late as November, and emerges in April or May. These two males have just come down to the warm lowlands where there is more food. The cubs remain with the mother for about two years and apparently take six or seven years to reach full size.

By the stream at right is seen a Pacific land otter, found from Oregon to Alaska. It swims in a series of leaps and dives, and likes to play on snow or clay "slides," down which it coasts on its chest headfirst into the water.

The volcanic mountainous background of this wonderful scene on the Alaska Peninsula dramatically illustrates the scooping action of glaciers and snow fields in producing U-shaped valleys and cirque-like cirques.



The descriptive text accompanying these displays was assembled by NATURAL HISTORY Magazine from information prepared for the hall by George G. Goodwin, G. H. H. Tate, T. Donald Carter, and John Eric Hill

AMNH photos by Thane Bierwert



Moose

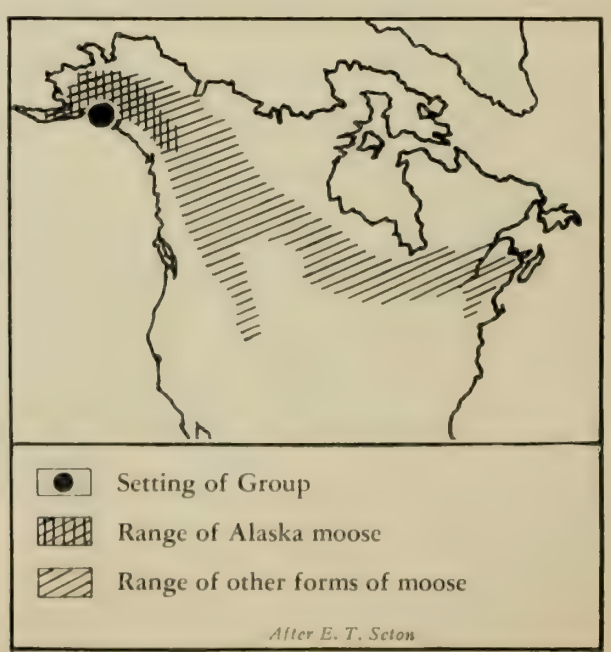
Alces gigas

Moose are the largest and grandest of the deer family. In the Kenai Peninsula and neighboring regions of Alaska, they reach their greatest size both in stature and in horn development. The antlers on the bull on the right in this group represent the world's record in size and have a spread of 77⅝ inches. New antlers are grown each year; the females have none. Males stand as high as six and one-half feet at the shoulders and weigh as much as 1400 pounds. The females are only about three-quarters as large as the males. Moose are found in nothern Europe, Asia, and North America.

During the mating season terrific battles occur when two rivals encounter each other, as shown above. The noise of a moose crashing through brush and fallen timber, pausing occasionally to thrash at the shrubbery with his antlers, gives one the impression that nothing can stop his massive advance.

Aside from man, the chief enemy of the moose is the wolf. The calves sometimes fall prey to bear and mountain lion.

Moose are forest-loving animals and prefer country with numerous lakes. In summer they enjoy wading into these lakes for protection from flies and mosquitoes and to feed on water plants. Moose are chiefly browsers, feeding on the bark, twigs, and leaves of maples, birches, alders, and willows.





AMNH photo by C. H. Coles and R. E. Logan

Bison and Pronghorn

Bison bison bison and
Antilocapra americana americana

THE photograph below is of a miniature model and illustrates the painstaking care with which every step is planned in the construction of a group. This exhibit, now nearly completed, faces the Moose Group along one side of the long central corridor of the Hall of North American Mammals. The scene is a historic one in Wyoming near where the famous Overland Trail crossed the North Platte River. It shows the well-known American bison, or buffalo, which once roamed over our Great Plains in countless millions, and the graceful pronghorn. The latter is the only antelope in the world with branched or pronged horns.

AMNH photo by [illegible]





AMNH photo by C. H. Coles

White Sheep

Ovis dalli Nelson

THE massive curling horns tell you that these are mountain sheep. Their pure white color indicates that they come from the North. Throughout Alaska, the coat of this animal is all white except for an occasional brownish stain. Farther south, in the Yukon, the coat darkens, until finally in northern British Columbia a very dark sheep is found. This sheep is the subspecies known as *stonei,* or Stone's sheep.

These animals are expert mountain climbers and are not found away from steep and broken country. They are extremely sure-footed and climb up and down precipitous slopes where a man could not hope to pass. The sound of dislodged stone may be the first notice that they are above, though the adult may indicate its presence by a snort, or the kid by a shrill blat. When frightened, their tendency is to climb to the most inaccessible cliffs for protection. They have keen vision and depend more upon their eyes than upon their ears or nose to detect an enemy.

White sheep live only above timber line and spend their lives in a limited area, descending from higher altitudes only when forced down by snows. They are active throughout the year and may be seen at any hour of the day, but they often lie down to rest or take the sun after feeding in the early morning, to resume grazing only late in the day.

Although these animals are true sheep, their coat is hairy and not woolly. The horns of the females are smaller.

A SUPERB coat of heavy hair protects the musk-ox from the extreme winter temperatures of its arctic home, and the animal is able to secure food by pawing away the snow from the mosses and lichens on which it feeds. Unlike the Barren Ground caribou, which migrates north and south with the seasons, the musk-ox remains in the far north throughout the year.

In the Pleistocene or Ice Age, musk-oxen ranged over most of Europe, Asia, and what is now United States, but they vanished from these regions before historic times. Even in the past hundred years or so, their remaining realm in arctic America has become definitely smaller. Man is the musk-ox's worst enemy and is chiefly responsible for this.

Musk-oxen are found in herds of from ten to 30, formerly in much larger ones. When attacked, the herd forms a circle with the calves in the center, thus presenting a formidable phalanx to wolves—but not to men with guns.

The shaggy coat makes it easy to overestimate the weight of a musk-ox, but bulls do weigh 600 pounds or more and measure five feet at the shoulders. One is apt to think of musk-oxen as a sort of cattle, but actually they are more closely related to sheep and goats. Their nearest relative is the Himalayan takin. Usually the cow gives birth to a single calf, late in April or May.



Musk-ox

Ovibos moschatus Zimmerman

AMNH photos by Thane Bierwert



Setting of White Sheep Group

Range of white sheep

Range of the blackish race of white sheep

Setting of Musk-ox Group

Range of musk-ox

After E. T. Seton





AMNH photos by Thane Bierwert

Mountain Goat

Oreamnos americanus Blainville

THE mountain goat is not a true goat but belongs to the goat antelopes, or Rupicaprinae, which includes also the chamois, serow, and goral of the Old World. His home is on the high, sheer peaks of the mountains, far above timber line. His outstanding accomplishment is his marvelous climbing ability. In this he even surpasses the mountain sheep. Traveling along precarious cliffs where other animals dare not follow, he is safe from his natural enemies,—wolves, bears, and mountain lions. The eagle may occasionally take a kid but only when it is left unprotected by its mother.

The kids are born in April or May, generally one to a mother but sometimes two. Within a few days after birth they are able to follow their dams.

The food of the mountain goat consists of mosses, lichens, bushes, and grass. He does not descend into the lower levels during the winter, as do the sheep, but finds sheltered spots among the rocks for protection against storms. The crag represented above overlooks Alaska's Sawyer Glacier.





Mountain Lion

Felis concolor Linnaeus

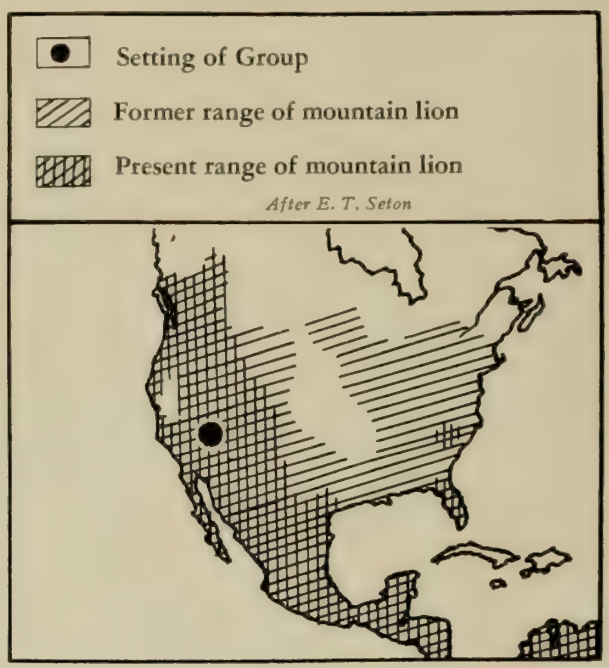
IN spite of his common names, which might indicate such a kinship, the mountain lion, cougar, puma, or "panther" has no close relatives in Europe, Asia, Africa, or Australia.

In the West the mountain lion prefers rough mountainous country, but it was formerly at home throughout the forests and rocky regions wherever deer occurred, from Canada to Patagonia.

Early settlers considered the big cat dangerous, but few attacks on mankind were recorded, and only a starving or cornered cougar is to be feared. They are shy and are rarely seen, even when common. Individuals will, however, follow a man for miles and prowl around camp, apparently from pure curiosity. They are readily tamed, especially when young, and remain docile and playful.

Cougars are usually found in pairs except for a short time after the birth of the young.

The background is the Grand Canyon, whose rock walls present the most complete record of earth history found anywhere in the world.



Grizzly Bear

Ursus horribilis Ord



THE name "grizzly" was given to this bear because of its unusual coloring. The word "grisly," meaning terrible, gruesome, or grim, was applied later but was evidently in the mind of Ord when he gave the grizzly the scientific name *horribilis*.

The grizzly bear is the most formidable and ferocious animal in North America, and yet, according to the best authorities, it rarely attacks man unless provoked. Its mentality is far inferior to that of the dog or wolf, but its powers of scent and hearing are highly developed. The favorite range of the grizzly is high rolling uplands, with rocky ridges and densely wooded thickets. Here it finds abundant food, consisting of roots, berries, nuts, insects, reptiles, fish, birds, eggs, and mammals ranging from mice to cattle. The young are born in the mother's winter den and are exceedingly small at birth. The second winter they den up again with the mother, but after that are able to shift for themselves.

Grizzly bears seem to communicate by a sort of signpost language. The bear bites a trunk high up, tearing the bark open crosswise, and often leaves five raking claw marks.



AMNH photo — Frank Lerman



AMNH photo — [illegible]



AMNH photo by Thane Bierwert

Grant Caribou

Rangifer arcticus granti Allen

THE animals in this group are a variety of Barren Ground caribou that are restricted to the Alaska Peninsula; thus they belong to a group having a wide distribution over the treeless tundra of the circumpolar regions. Caribou are the only deer in North America whose females have antlers. Both sexes shed their antlers annually.

The winter coat of this animal, with its thick growth of air-filled hairs, is weatherproof and affords fine protection from the cold. The large, spreading hoofs are suited for travel over the soft muskeg in summer and the deep winter snows where other hoofed animals would sink and flounder.

The life of the northern caribou is one of continuous travel. It summers on the tundra along the Arctic coast and migrates south for the winter months in immense herds, to the border of the forest belt. In the summer its food is grass and in the winter, lichens. The mating season is October, and the young are born in June.

The most formidable enemy of this caribou is the great white wolf, but bear, wolverine, and other predatory animals take a limited toll. During the summer months insects are a great menace to all caribou.

The caribou is an important source of subsistence to the people of the arctic regions, both in food and clothing.

Big-horn Sheep

Ovis canadensis Shaw



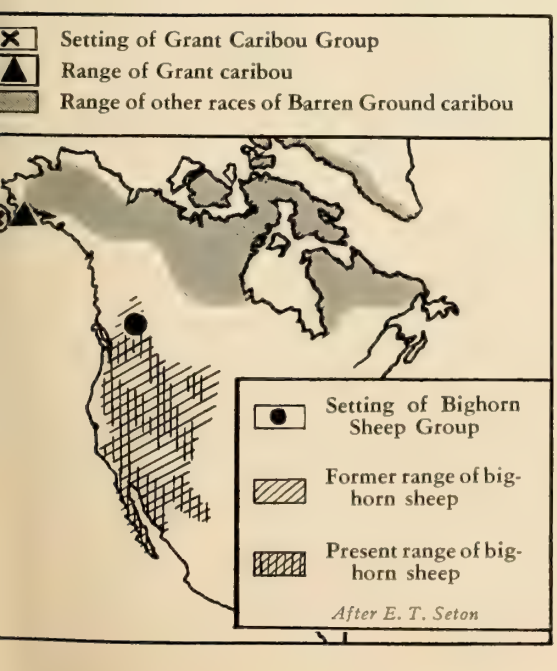
AMNH photo by Thane Bierwert

THE most coveted prize of the American big-game hunter, the bighorn sheep, inhabits the rugged mountains far above tree line and only descends when forced down by deep snow. Throughout most of the year, the older rams go about in small parties, keeping to themselves, while the ewes, lambs, and young rams form separate flocks. In late November the rams join the ewes, but after the breeding season they return to their former mode of life. The lambs are born in late May or June.

Besides man, the bighorn has many enemies. Coyotes, wolves, bears, mountain lions, lynxes, wolverines, and eagles,—all prey on the lambs, and the larger carnivores all enjoy a meal of mutton.

The horns on the right-hand ram *(also above)* are the world's record—49½ inches along the curve—and were donated by Dr. Henry M. Beck.

The scene is Jasper National Park, Alberta, and shows Mt. Athabaska as seen from the slopes of Mt. Wilcox at about eight o'clock in the morning.



AMNH photo by C. H. Coles and Thane Bierwert



Triumph of the Mammals

By EDWIN H. COLBERT
Assistant Curator, Department of Paleontology



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THIS FANTASTIC CREATURE unwittingly sports a "V for victory"—a victory in that world of outlandish horns 50 million years ago. But his imposing array of ornate points, prongs, and bumps, was no security to *Synthetoceras* when a new life of sudden changes confronted him. With him a long line of strange beasts quietly expired



ALL DRAWINGS BY MARGARET COLBERT



(Right) STRANGE, LONG-FACED PECCARIES once lived in Nebraska

(Opposite) A "conservative" of the Age of Horns: *Sphenophalos* may well have been an ancestor of the persistent line of North American antelopes, of which the pronghorn is sole survivor

CIRCUS without spectators

No human eye witnessed the parade of strange creatures in that age of superspecializations, but science reconstructs the surprising pattern from which our modern animals emerged

By EDWIN H. COLBERT

Assistant Curator of Vertebrate Paleontology, The American Museum of Natural History

FOR millions of years after the disappearance of the last dinosaurs and on through the long period during which archaic mammals were dominant on earth, the geologic history of North America, of the world for that matter, progressed in a steady and, one might say, comparatively placid fashion. Lands that were low and tropical when the mammals first began to flower were gradually uplifted to become high, grassy plains. Imperceptibly the mountain chains of the West came into being. The entire continent slowly pushed up and up until the landscape took on those features of hill and vale, mountain and plain closely resembling its present-day lineaments.

And with the implacable evolution of the continent toward its more modern form there were concurrent developments among the mammals, which had inherited this strange new world from their reptilian ancestors.

The mammals, it will be remembered, are the warm-blooded animals which generally give birth to living young instead of laying eggs and are able to nurse their offspring through earliest infancy. The importance of this chapter in evolution is evident when we realize that it concerns the ancestry of our most familiar four-footed animals of forest and plain.



At first changes were slow, as Doctor Simpson has pointed out in the two preceding chapters of this story. There was a long period of "experimentation" following the Great Invasion of more modern mammals into the New World, a period when Nature seemed to be trying out various models of animals, apparently in an effort to determine the forms most suitable for a continued existence in a fiercely competitive Scheme of Life. Many of the early experimental models were tried and many were found wanting, but out of the great melange of strange, primitive beasts which evolved between 40 and 60 million years ago during the earlier phases of the Tertiary period, some forms, more adequately fitted for continuation than their contemporaries, survived to give rise to the great mammalian faunas of later Tertiary times.

The later phases of the Tertiary period, notably the Miocene and Pliocene epochs, were pre-eminently the Age of Mammals. This was the time for the culmination of many lines of mammalian descent; it was the time when the earth was inhabited by hordes of beasts of different kinds and of high specializations. These numerous four-footed mammals, many of them of peculiar form and aspect, truly reigned supreme, for at that time there was not yet the unquiet and disturbing biped known as Man to contest their rule of the earth. They lived their separate but integrated lives unseen by the avid human eye. They marched and countermarched in imposing array across the face of the continent in processions of magnitude. They were the menagerie of an ancient circus without spectators.

These animals of the late Tertiary were for the most part wonderfully adapted to the environments in which they lived. They were suited to almost every conceivable "ecologic niche" of the late Tertiary world—that is, they were specialized to varied modes of life on the plain and in the forest, to grass-eating and to meat-eating, to burrowing and to climbing, to protection by virtue of their great size, and to escape by running. All of the exigencies of life on the land were met by the evolutionary development in these animals. Like the animals of our present-day world, these late Tertiary mammals had become modified to take advantage, each in his own fashion, of the varying conditions around them.

They were like the mammals of our present-day world, yet unlike them. True enough, many of them

were the ancestors of our modern types of animals and as such were intermediate between their earlier ancestors and their present-day descendants. They were distinctly and greatly advanced over the animals of early Tertiary times from which they had sprung, yet they were still sufficiently lower than their modern grandchildren to appear noticeably primitive to the modern eye. On the other hand, many of the animals of late Tertiary times were end products in themselves and had developed along lines that seem to us strange and bizarre; they were the rococo designs in mammalian architecture.

What was the world like in those distant days? Were not the inhabitants of an earlier land than ours strange and wonderful to behold? Let us project ourselves back through the mind's eye to a scene in the western part of North America of that ancient day—say some seven or eight million years ago, at about the beginning of the Pliocene epoch.

In those days the high plains of the West were not greatly different in appearance and development from what they are today. There were extensive rolling grasslands cut into mosaics by shallow streams, along which grew fringes of trees and small bushes. The climate was warm and fairly arid, perhaps without the extremes of temperatures that are so characteristic of that region today. Very likely the winters were considerably less frigid than our modern winters, so that there was in North America an environmental condition not unlike that of the modern African veldt.

Most apparent in the scene of that day, even as now, would have been herds of hoofed mammals that lived on the open prairie, and of all the later Tertiary mammals perhaps none were more markedly different from their modern counterparts than these grass-eaters.

Rhinoceroses in Nebraska may seem to be something of an anachorism to us, but there they were. Not the rhinoceroses of today, but heavy squat short-legged animals, ungraceful and almost hornless. It may be that these were water-loving rhinos, spending much of their time along the shallow watercourses of those ancient plains.

Drifting across the grasslands were herds of horses, —unmistakable horses, but horses in miniature. For these later Tertiary horses, though various, were all of pony size. Some of them were of the three-toed type, the persistent and conservative followers of their ancestors of ages long past; others were the more progressive single-toed horses, foreshadowing in form and structure their descendants of modern times.

Peccaries lived in ancient Nebraska, not the peccaries that we know from our modern tropical and subtropical America, but large, long-faced peccaries, many of them with large projections or bumps on their cheeks, so that they must have looked something like the wart hogs of present-day Africa.

If the rhinoceroses of later Tertiary times may be styled as "sawed-off," the North American camels of that age were just the opposite, the slim-jims of their day. These were greatly elongated animals, with stilt-like legs and giraffe-like necks, towering into the rarified upper strata of the available food supply. And though strange of form, these perpendicular camels should not be regarded as strange in their occurrence, for the entire heritage of these animals was peculiarly North American. Here they arose and developed, and it was only at a later date, in the great Ice Age, that the camels emigrated from their North American homeland to newer lands, finally to become extinct in the land of their origin.

Here also were the last of the oreodonts, a group of hoofed mammals that lived and developed through a major portion of the Tertiary period. They were unlike anything now living, rather short-legged animals, some of them as large as sheep. The head was remotely sheep-like, rather deep and without any horns or bony outgrowths; and they had four well-developed toes on each foot, and a long tail.

But strangest of all the varied grass-eaters of those distant plains were the numerous horned and antlered forms. In some of these animals evolution seemed to have "gone on a bender," for nothing like these animals should reasonably be expected outside the world of dreams or of delirium tremens. Here were deer-like animals with "horns" or "antlers" of a bewildering variety. Many had the usual pair of such structures at the back of the head above the eyes, in some cases curved in, in other cases curved out, in some cases directed backward, in other cases pointing forward; but others had prongs and points jutting out of all sorts of strange and unexpected places on their skulls, which gave them nightmarish aspects, to say the least. Our knowledge of these peculiar horned animals has been greatly augmented in recent years by the collections of the Frick expeditions of the American Museum—indeed, a whole new world of peculiar mammalian types has been opened up as a result of this work.*

This was an age of *three-horned* animals, of beasts which sported a single median horn in addition to the usual pair above the eyes. One of these triple-horned grazers, *Synthetoceras* by name, had two very adequate and ornate structures over the eye sockets and then, as if this weren't enough, he had an unbelievably long prong, forked at its tip, projecting up from the front of the nose. In addition he had a couple of small knobs on the sides of the skull. And then to supple-

* *See* Childs Frick, "Horned Ruminants of North America," *Bulletin of the American Museum of Natural History*, LXIX (1937).

ment this array of points, prongs, and bumps, a pair of well-developed canine teeth or tusks peeped out from beneath his fleshy upper lip. Needless to say he was one of those end products of evolution, and with him a long line of strange beasts quietly expired. Which is our loss, for he must have been something to look at. Bounding along with his head up before the prairie wind on a stormy day, he must have looked like some sort of peculiar three-masted schooner with all of the canvas hauled down.

Another one of these unorthodox grazers had a third horn growing right out of the back of his skull, like the stern flagpole of a small ship. Our knowledge of this animal, known as *Cranioceras,* came about as follows: a score or more years ago, the late Dr. W. D. Matthew, then Curator of Fossil Vertebrates at the American Museum of Natural History, found in northwestern Nebraska the single median horn of this animal and recognized it for what it was. He named the animal on the basis of this fragment, and predicted what might be expected when the entire skull should be found. Many years later, not one but several skulls of *Cranioceras* were found by the Frick parties, and they showed a median horn, as Matthew had prophesied, but they also showed what Doctor Matthew had no way of guessing, namely the additional pair of horns above the eyes. Even so, this confirmation of Doctor Matthew's shrewd prediction indicates the depth of knowledge and perception possessed by that great paleontologist.

Of course not all of the horned animals were quite so outlandish as these three-horned fellows. Indeed, some of the horned grazers of that distant day were relatively conservative, and as might be expected these were for the most part the ancestors of persistent evolutionary lines. For instance, there was a large variety of antilocaprids, of which our modern pronghorned antelope is the sole survivor. Some of these early antilocaprids were rather deer-like, with branched "antlers" on their skulls, but others, although tending to favor the ornate in their horn development, were even then prophetic of the pronghorn. There were other horned grazers, too numerous to mention, but perhaps this gives some idea of what might be expected of these animals in North America during the Pliocene age, several million years ago.

It was an age of horns—even the rodents had them. In the late Tertiary deposits of the high plains there was a whole series of horned gophers characterized by transversely paired horns on the nose.

Grazing and browsing with the hoofed mammals on the open plains were the tusked and trunked mastodonts, the Tertiary forerunners (but not the ancestors) of our modern elephants. There were several kinds of these, most of them characterized by four tusks, two in the upper jaws—as in the mod[illegible] phants— and in addition two in the lower jaw, [illegible] was greatly elongated. All of these long-jawed [illegible] todonts were peculiar, but perhaps the prize of the l[illegible] was the animal known as *Amebelodon,* the so-call[illegible] "shovel-tusker," in which the lower tusks were [illegible] rounded in the orthodox fashion, but flattened to form broad scoops, enabling these animals to poke around in the mud and among shallow-water plants of the prairie streams for their food. In addition to the peculiarity of its tusks, the lower jaw of *Amebelodon* was unbelievably long, and one wonders how this animal negotiated hillocky ground without constantly ramming his lower tusks into the earth like a broken down wagon-tongue. At any rate, *Amebelodon* did exist, there are his bones to tell us so, and he was seemingly successful for a while. It is probable that the trunk of this animal was not round as is usual among the proboscideans or elephant-like animals, but flattened, a sort of elongated upper-lip,—which is really what it was.

No picture of animal life is complete without the beasts of prey which live upon the grass-eaters. And there were many such hunters in Nebraska of long ago. But they did not show the bizarre developments so apparent among the grazers. Here we come into the realm of ancient dogs, some of them ancestral to our modern wolves and foxes, others of gigantic size —obviously the culminations of lines long in the process of evolution. Here were the late Tertiary cats, of different sizes but not so very different in form from our modern felids, except for those of the sabertooth variety, with their great, scimitar-like canine teeth. Here were the weasels and their ilk, the badgers and the skunks, the raccoons and all of the various lesser carnivores that found their living off the small rodents and other small fry which scampered along miniature runways through the grass roots, or sought protection beneath the soil in subterranean burrows.

Such was the Parade of Life long ago—a parade of forms both familiar and strange to the eye of modern man. In it were the ancient dogs and cats, the various gnawing rodents, the horses and other animals, marching toward a future of continued evolutionary development. But also there were in it the peculiar short-limbed rhinoceroses, the stilt-legged camels, the shovel-tusked mastodonts and the host of bizarre horned ruminants marching toward the oblivion of extinction.

Why should this be? Why should those delightfully strange beasts die out at a time when they seemingly were riding along so successfully on the crest of a wave of evolutionary development? Why did they disappear, to be succeeded in modern times

by forms which to us seem by comparison so prosaic?

Perhaps it was the trend of evolution. The climate was becoming increasingly severe, the land was losing some of its long-established geniality. The lush life of the warm plains and the woodlands was over; a new life of fluctuating temperatures, of ice and of snow was in the offing. Conditions were changing, and changing at such a rate that these highly specialized animals with their shovel jaws, their short legs and long legs, and their varieties of horns and prongs could not make the adjustments necessary to survive the gathering changes, so they gradually died out, to make way for what we are pleased to call the "modernized" types that succeeded them. It is the old, old story that is told time and again in the record of the rocks. Only the fit survive, and when the environment begins to change, the fit are those which can change with it or adapt themselves to the new conditions that are being established. The highly specialized animals, no matter how well organized they may be for existence under the old conditions, must pass into the limbo of the dead if they cannot meet the stringencies of new conditions.

So it was that numerous denizens of America succumbed in the final stages of the Tertiary period. They disappeared before a new horde of beasts—a horde that came in with cold winds from the north, with the ice and the snow.



EVEN THE RODENTS had horns. Transversely paired horns on the nose were characteristic of the late Tertiary gophers that scampered over the western high plains of North America

(Below) NATURE'S LONG PERIOD of "experimentation" included a squat, "sawed-off" rhino and a mastodont whose peculiar flattened tusks distinguished him as the "shovel-tusker"

Drawing by R. Bruce Horsfall from *A History of Land Mammals in the Western Hemisphere*, by William B. Scott (Macmillan)



Ice-Age Mammoths

and their descendants—

All drawings by MARGARET M. COLBERT



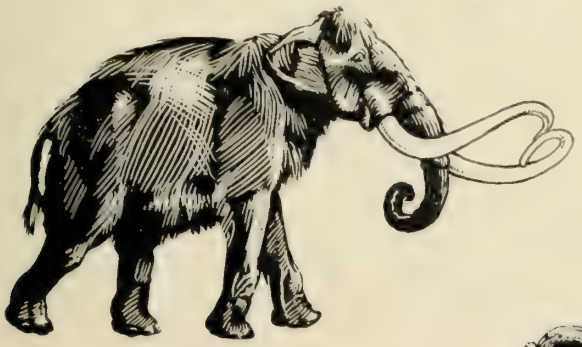
(*Right*) WOOLLY MAMMOTH (*Elephas primigenius*); mammoth north circumpolar; Eurasia and North America



STRAIGHT-TUSKED MAMMOTH (*Elephas antiquus*); a mammoth of the Old World



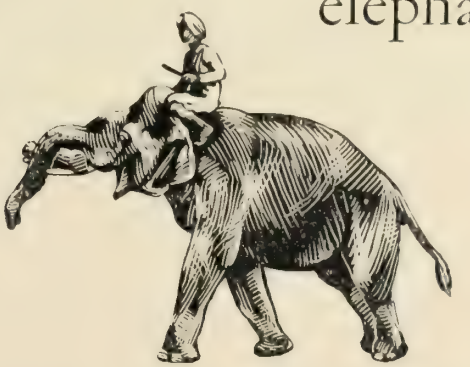
IMPERIAL MAMMOTH (*Elephas imperator*); southern North America



COLUMBIAN MAMMOTH (*Elephas columbi*); the large mammoth of middle North America

(*Right*) INDIAN ELEPHANT (*Elephas maximus*); the survivor of southeastern Asiatic mammoths

the modern elephants





AFRICAN ELEPHANT (*Loxodonta africana*); survivor of mammoths of Eurasia and Africa

ICE-AGE CARNIVORES





The beasts of prey were less bizarre than the hoofed animals that grazed across the plains of ancient North America. The grandfather of the raccoons (Phlaocyon) resembles the living cacomistle or ringtailed cat (Bassariscus) of Mexico and our Southwest.

In late Tertiary America lived *Hemicyon*, a "bear-dog." As large as a black bear, this animal possessed an admixture of dog-like and bear-like characters which make it an almost perfect intermediate form between the early dog-like carnivores and the modern bears.



LONG BEFORE WHITE MAN set foot upon our shores, horses and tapirs had left North America, presumably for "greener pastures." But while the fourth great glacier was refrigerating most of the continent, both these plant-eaters were content to bask in Florida's mild climate

ICE AGE WINTER

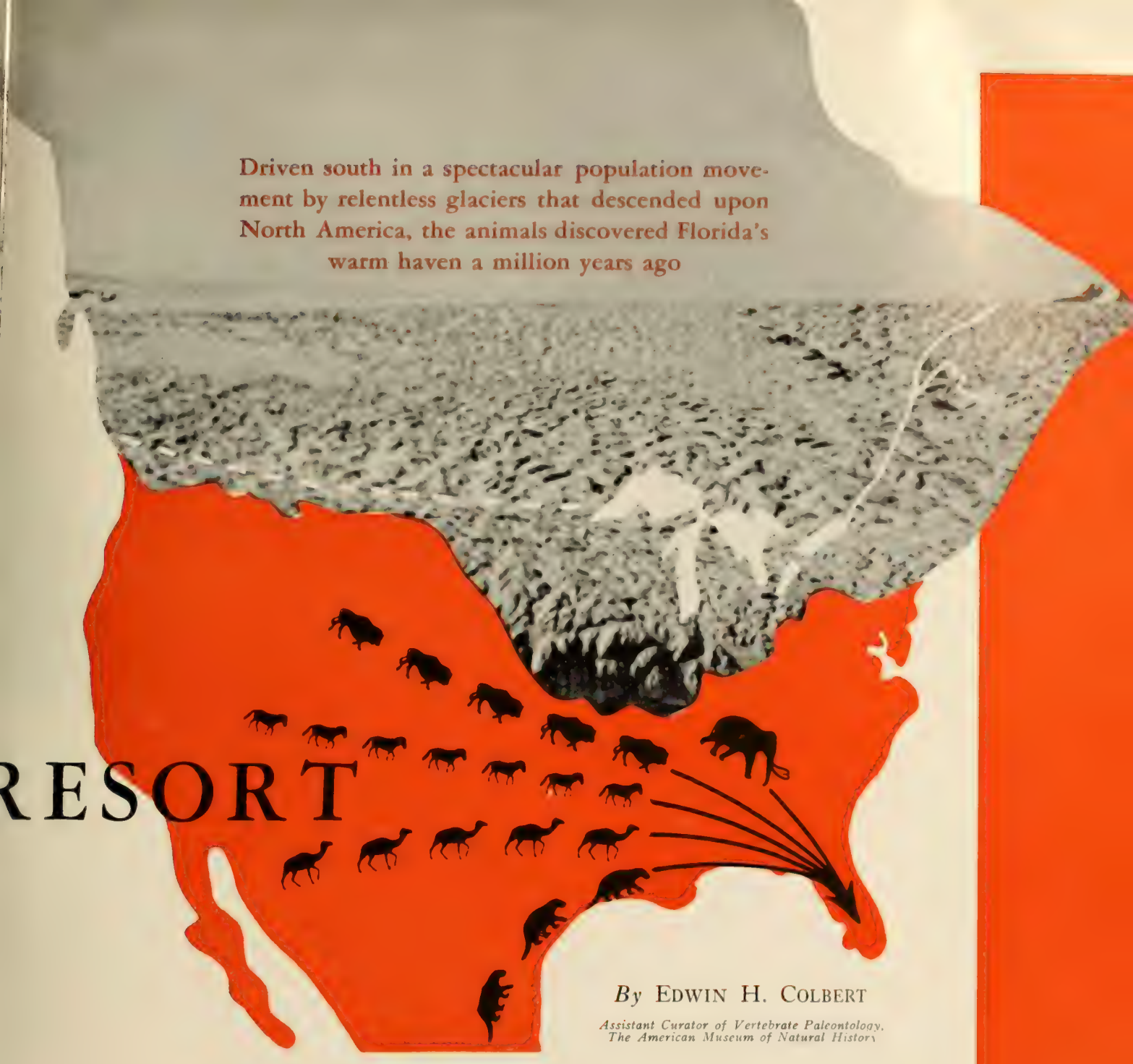
DRAWINGS BY
MARGARET COLBERT



ARCH-PREDATOR of the Ice Age was the powerful saber-tooth. Small-fry ice refugees —the otters, skunks, weasels, etc.—lived in terror of this giant cat. The capybara (*right*) found a haven along the Floridian streams. Though extinct in North America, this colossus among rodents persists in South America

RESORT

Driven south in a spectacular population movement by relentless glaciers that descended upon North America, the animals discovered Florida's warm haven a million years ago



By EDWIN H. COLBERT

Assistant Curator of Vertebrate Paleontology, The American Museum of Natural History

ABOUT a million years ago there began a series of new events of profound importance in the history of the earth. From the north, tremendous glaciers—icecaps of continental proportions—began to creep slowly southward to engulf the greater portion of North America, while at the same time in Eurasia, there was a similar southward advance of the ice sheets. These glaciers of the northern hemisphere pushed unceasingly down to the middle latitudes, and then, just as mysteriously as they had begun their advance they halted, and finally retreated to the polar regions from whence they came.

Four times this great encroachment of the land by continental glaciers occurred, and North America, Europe, and northern Asia became regions of polar frigidity. Four times the glaciers retreated and the northern continents became warm again. It is in the last of these glacial retreats, which began some 30,000 years ago, that we are now living. We are the inhabitants of a warm interglacial age, and there is no reason to think that our descendants, in the dim future, may not witness another southward push of the ice, inevitable and relentless. All of which is in explanation of the latest events in the long history of the earth, the great Ice Age which is known as the Pleistocene.

Obviously the first glacial advance, bringing with it cold, arctic conditions, was bound to have some effect upon the animals living in the northern continents, in North America, Europe, and Asia. The long period of gradually changing environmental conditions described in the first chapter of this pamphlet was at an end; here was the beginning of a new epoch, a period of relatively rapid changes in environment. To the new conditions the life of the earth had to adjust itself.

As has already been shown, many types of strange animals became extinct near the end of Pliocene times,

even before the glacial advance had truly begun. The increasing rigors of the climate preceding the actual formation and southward push of the vast continental glaciers must have had much to do with the disappearance of the strange, highly specialized mammals of late Tertiary times. Consequently by the beginning of the Ice Age in the northern world many "modernized" types of mammals had made their debut upon the stage of paleontologic history, animals which were fitted by their adaptability to withstand the rapid and severe changes attending the first great glaciation.

The horse and his relatives the asses and zebras appeared with the advent of the Ice Age. So did the camels and the large deer of our modern world. So did the various cattle, and with them a host of antelopes and gazelles. So did the elephants. Indeed, the sudden appearance of these new, modernized types of animals affords one of the convenient ways for recognizing the opening of the Ice Age throughout the world. The words "throughout the world" give a true impression, for a striking feature of this period was the great intercontinental and in some cases world-wide movements of certain types of these new, modern mammals. Let us look for a moment at these "migrations," if so they may be called.

The horses had evolved in North America during the long reaches of the Age of Mammals. Suddenly with the beginning of the Ice Age they broke from the confines of their homeland to spread through virtually the entire world. To the south, they pushed across the newly-established isthmus to occupy all of South America. To the west, they poured across a land connection which at that time bound Alaska to Siberia, and spread throughout Eurasia, the Orient, and Africa.

With them went the camels and their relatives. The llamas, alpacas and their ilk went to South America, the large camels to Asia, the Orient, and Africa, again utilizing the Isthmian and Bering crossings which connected the continents.

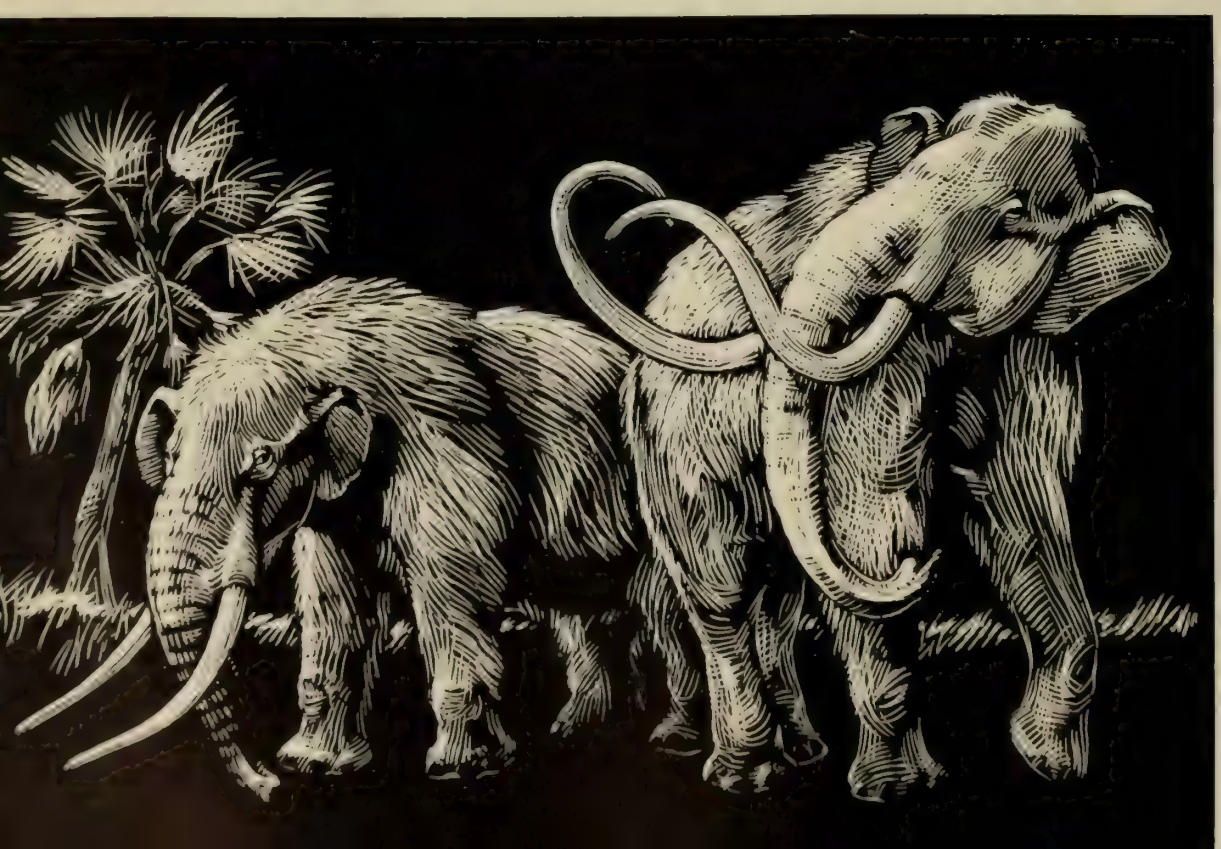
But all of the movements did not originate in North America, for there were corresponding flows in the other directions. The elephants, whose Pleistocene representatives are known as mammoths, originated in the Old World and crossed the Bering Bridge into the New World to occupy all of North America. With them came the cattle, specifically the bison, an immigrant which we think of as being the veritable symbol of America.

Bears and large deer also came from the Old World into the Western Hemisphere, although forerunners of these animals already inhabited this region; while from the opposite direction gigantic ground sloths, which had been evolving in South America, crossed the Isthmus to take up a new abode in a northerly environment.

These are only a few of the great movements of animals that took place with the coming of the Ice Age, but perhaps they indicate the extent to which the early Pleistocene was a period of animal migrations. Newly evolved animals pushed from one land to another, from north to south and south to north, from east to west and west to east. It seems as though a shuffling of animal populations was necessary to strike a new balance in the changed world.

These were the great movements that heralded the opening of the Ice Age. But what happened after these initial phases of the Pleistocene period had run their course?

We have already seen how there were four glaciations, how the ice advanced four times from the north polar region and how after each advance it retreated to the far north again. With these advances and retreats of the glaciers there were corresponding movements of the mammalian populations. As the ice came down from the north the mammals withdrew southward ahead of the glacial front. Then, during the interglacial stages, as the ice retreated to polar regions, the mammals spread northward again to occupy those regions from which they had been driven by the polar cold. Thus the Pleistocene animal populations may be thought of as pulsating communities, ebbing and expanding as the glaciers advanced and retreated, constantly shifting back and forth as the



MASTODONS AND MAMMOTHS also pushed their bulky weights to the Ice Age Winter Resort. Though conditions seemed ideal for their continuation, both disappeared from earth—leaving science with still another tantalizing "why?"

environment changed. Theirs was a life of rigorous changes, not within the experience of the individual it is true, but within the existence of the species. Such was the story of mammalian life in North America during the fluctuating course of the great Ice Age.

In all but one corner of North America—for in one small area the history of mammalian life seems to have differed from its general course over the rest of the continent. This is in what we may call the Ice Age Winter Resort—the peninsula of Florida.

As the glaciers pushed down from the north and crowded the animals before them, the influx of life into the southern portion of North America caused added pressure and competition during the glacial stages. Somewhere, somehow, a balance must be attained, or the pressure of animal populations would reach an explosive state. This balance was found, very likely, in the "safety valve" of Mexico and the Central American region. As the animals pushed in from the north, the southern animals retreated as best they could into the lower end of the North American horn. Thus by constant movements and adjustments the various animal populations could become more or less established in progressively smaller areas.

But on the eastern side of the continent such adjustments could not be made. Florida offered a warm haven for animals driven south by the polar cold, but it was a "dead end." Moreover it was a relatively small area, so that its accommodations for immigrating animals were necessarily limited. Consequently there seems to have been little penetration from the north, and life went on in Florida during the Pleistocene undisturbed by the flowing and ebbing glaciers. Here was an old-fashioned environment, with the rather monotonous conditions of existence that had prevailed over much of North America in earlier geologic ages. Here the tenor of life continued much as it had in the past.

To the eye of imagination, what would the Florida scene of that age look like? Very much as it does today, with certain additions. As in present-day Florida, there would be a host of small animals inhabiting the underbrush and hammocks [illegible] grass out of sight of the predator's eye. [illegible] be opossums and shrews, rabbits and [illegible] wild mice, muskrats, and squirrels. B[illegible] around in the streams in decided contrast to [illegible] rodent brethren would be the large capybara, [illegible] giant among the rodents, now living far to the [illegible] in South America.

There would be numerous hunters such as [illegible] found in Florida today, the gray fox, skunks, [illegible] weasels, raccoons, otters, and lynx. But dominating these pilfering seekers of small prey would be great powerful predators such as one would hardly care to meet at close quarters. Fierce wolves would be seen loping across the hard open ground, while gigantic bears, long since extinct, would be found in the thickets. Great cats would be seen gliding through the forests like wraiths: the jaguar, found now in lands to the south, and the powerful saber-toothed cat, arch-predator of the Pleistocene, which disappeared from the earth thousands of years ago.

It is among the more peaceful types of animals, the grass-eating and browsing forms, that the Pleistocene fauna of Florida would seem strange to our modern eye. First one would encounter the bizarre giant ground sloths and the glyptodonts, immigrants from the south and cousins to the armadillo, an immigrant that still lives in this region. These were stupid and inoffensive animals, depending largely on their size for protection. The giant sloth probably could ward off the aggressive saber-toothed cat by using his hook-like claws, while the glyptodont, covered with a turtle-like shell, could pull in his head and offer passive but effective resistance to the enemy.

Then there would be the horses and tapirs, both living elsewhere today, but both destined to become extinct in North America long before white man set foot upon these shores. The horses fed in the open glades, while the tapirs, like their modern relatives, probably stayed along the streams, splashing through the water and browsing on the succulent leaves hanging over the banks. In the wooded stretches there



"NAILS IN HIS GLOVES." The hook-like claws of the giant ground sloth enabled him to ward off the attacking sabertooth. The turtle-like shell of the strange glyptodont (*right*) offered passive but effective resistance

were large peccaries, pig-like animals whose much smaller cousins survive today in southern North America and the regions to the south. In the open spaces camels would be seen, grazing alongside herds of deer and black masses of large bison. And in the streams, sea cows and alligators would raise their heads as they swam along, even as they do today in Florida.

Finally there would be the gigantic elephant-like animals, the mastodons and the mammoths, crashing through the forests and stripping leaves from the trees with their powerful trunks. These were the dominant but tolerant lords of the entire scene, afraid of nothing but the elements.

Such was Florida in the Pleistocene. And such was North America during the warm interglacial stages of the Ice Age. The difference was that this picture continued in Florida with but little change throughout Pleistocene times, whereas over much of North America the landscape was altered by the advance of the glaciers. At such times many of the animals that enjoyed a relatively tranquil existence in the Ice Age Winter Resort of the peninsula were in other regions driven to the south by encroaching reindeer, muskoxen, giant beavers, and woolly mammoths.

Such was the Florida that was found by the distant forerunners of Ponce de León—the first men to come to America from Asia. That was many thousands of years ago—how many we do not know. What we do know is that early man in Florida was



living with all of these animals, with the types which still exist in this region and with those giants which long since became extinct in this land—the horse and tapir, the capybara, the saber-toothed cat, the ground sloth, the camels, the mastodon and the mammoth.

Why should these animals have become extinct, particularly in a land that seemingly was so amenable and so well suited for their continuation? This is a tantalizing question to which we shall probably never know the full answer. Suffice it to say that the great, dominant mammals of the Pleistocene became extinct all over North America *after* the arrival of man on this continent. Did man have anything to do with their disappearance?

Whatever the cause, the fact is that they did become extinct, but not until after the [illegible] begun its retreat to the north. [illegible] period of our earth history [illegible] the Ice Age Winter Resort for the Pl[illegible] mals became the winter resort [illegible] rest of the continent, [illegible] ing cold and warm epochs, again [illegible]

But are we at the end of the cycle? We [illegible] but that in some future period, [illegible] of years hence, our descendants, [illegible] civilized by that time, will really find Florida [illegible] than a winter playground? Perhaps it will be [illegible] them a haven, far removed from the [illegible] front of the fifth continental glacier, [illegible] over our northern cities.



Reading List

Bradley, J. H. *Parade of the Living.* New York: Coward-McCann, 1930.

Colbert, Edwin H. "Nebraska — Fifteen Million Years Ago," Natural History Magazine XXXV, 1935, pp. 37—46.

Colbert, Edwin H. "Mammoths and Men," Natural History Magazine, XLVI, 1940, pp. 96—103.

Fenton, Carrol Lane. *The World of Fossils.* New York: D. Appleton-Century Co. Inc., 1933.

Fenton, Carrol Lane. *Life Long Ago.* New York: Reynal, Hitchcock, 1937.

Knight, Charles R. *Before the Dawn of History.* New York: McGraw-Hill, 1935.

Lucas, Frederick A. *Animals of the Past.* 7th edition. New York: American Museum of Natural History, 1929.

Lull, Richard Swann. *Organic Evolution.* 2nd edition. New York: Macmillan & Co., 1929.

Matthew, W. D. *Climate and Evolution.* 2nd edition. New York: New York Academy of Sciences, 1939.

Matthew, W. D. and S. H. Chubb. *The Evolution of the Horse.* 7th edition. New York: American Museum of Natural History, 1927. 1939.

Raymond, P. E. *Prehistoric Life.* Cambridge: Harvard University Press, 1939.

Romer, Alfred S. *Man and the Vertebrates.* 2nd edition. Chicago: University of Chicago, 1941.

Scott, W. B. *A History of Land Mammals in the Western Hemisphere.* 2nd edition. New York: Macmillan & Co., 1937.

INSECTS, TICKS AND HUMAN DISEASES

by

C. H. CURRAN *and* FRANK E. LUTZ



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ROY W. MINER, *Chairman*



INSECTS, TICKS AND HUMAN DISEASES

A Brief Statement of Facts
Vitally Important to Man

by

C. H. CURRAN *and* FRANK E. LUTZ

The American Museum of Natural History
GUIDE LEAFLET No. 113
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INSECTS, TICKS, AND HUMAN DISEASES

by

C. H. Curran and Frank E. Lutz

One of the varied and exceedingly important relations between man and insects is the transmission of serious human diseases by a relatively few kinds of insects. In some cases the transfer is purely mechanical; in other cases the insect is an essential part of the development of the disease. During war, when men gather in large numbers or enter regions containing diseases to which they are not immune, the seriousness of the spread of diseases by insects is greatly increased.

The Diptera are by far the most important disease-carriers among the winged insects. Unlike most other insects, Diptera never have more than one pair of wings. They are the flies, mosquitoes, and midges. Fleas and lice, all wingless, are the other insects that are outstanding in this connection. Ticks, which are not insects, are also very important carriers of disease.

DIPTERA

The mosquitoes may be known by the long, piercing, sucking mouth (proboscis), and the presence of scale-like hairs on the wings. They are moderately fragile and have long slender legs.

The midges are generally more delicate than mosquitoes. They lack the scales on the wings and even those that bite (some very small ones) have rather short mouthparts. Some of the larger midges are often mistaken for mosquitoes; but, since they do not "hum" and are not attracted to people, they are soon recognized as harmless.

"Flies" is a general term applied to the more robust members of the Diptera, regardless of size. The term is perhaps best exemplified by the house fly, green- and blue-bottle flies, and other flies in houses, and by the deer and horse flies that attack people in the woods. There are many thousands of different kinds of flies but only a relatively small number of them bite.

MOSQUITOES

The mosquitoes are divided into three main groups but only two, the Anopheline and Culicine, are important. There are disease carriers in both groups. The Anopheline group is well known because some of its members transmit malaria. The mosquitoes that carry yellow fever belong to the Culicine group. Other diseases are transmitted by members of each group.

Anopheles mosquitoes are readily distinguished from other adult mosquitoes because they have the scutellum almost evenly convex apically; the abdomen is usually without scales or they are few in number. When an *Anopheles* is at rest the body is held at an angle of about 45°. The wings of most species are spotted. The eggs

are laid singly or in loose masses and have characteristic floats. The larvae are surface feeders and rest with their bodies parallel with the surface of the water.

Culex, Aedes and other Culicines have the scutellum concave toward the sides so that it is trilobed; the abdomen is wholly covered with scales. When these mosquitoes rest or bite their body is parallel to the surface. The wings of only a few of the species are spotted. The eggs may be laid singly, in loose masses, or in compact "rafts" but they do not have individual floats. The larvae rest at an angle to the surface of the water.

MALARIA

It has been authoritatively stated that malaria is "a disease of world-wide incidence and the cause of a higher sickness and death-rate than any other disease" (Encyclopaedia Britannica). In addition to deaths directly due to malaria, the disease weakens its victims, destroying their efficiency and making them more susceptible to other diseases.

A malarial parasite in man was first identified in 1880 by Charles Louis Alphonse Laveran, a French military physician then serving in Algeria. He received the Nobel prize for medicine in 1907. The parasites are one-celled animals of the genus *Plasmodium*, distantly related to amoebae. Their lives in the human body are relatively simple. An individual parasite enters a red blood cell and feeds on the cell's contents. When fully grown the parasite divides into a number of parts, each part being a new individual parasite. These youngsters break out of the blood cell in which they were formed and, for the most part, each of them enters another red blood cell to repeat the "asexual cycle." However, some of them, instead of being sexless, are either male or female. These sexual individuals float about in the blood stream and eventually die unless one of certain kinds of mosquitoes sucks them into its stomach.

The part played by certain mosquitoes in the transmission and, indeed, in the propagation of malaria was made clear in the last three or four years of the nineteenth century by the work of MacCallum (an American working on malaria in birds), Manson, Ross, Grassi, Bignami, Sambon, Low and others. It is briefly as follows.

Not all of even those mosquitoes that suck human blood are involved in the malarial cycle that includes man. There are apparently some exceptions to the usual statement that it must be a species of the genus *Anopheles* but, on the other hand, not all of the species of *Anopheles* are involved.

When a mosquito sucks blood from a malarial patient the mosquito is almost certain to draw into its stomach some of the sexual forms of the malarial parasite. Then, if the mosquito is one of those kinds that are susceptible to malarial infection, male and female forms of the parasite unite and the resulting organism bores through the lining of the mosquito's stomach and remains for a while as a cyst in the muscles of the stomach. Numerous spore-like bodies (sporozoites) develop

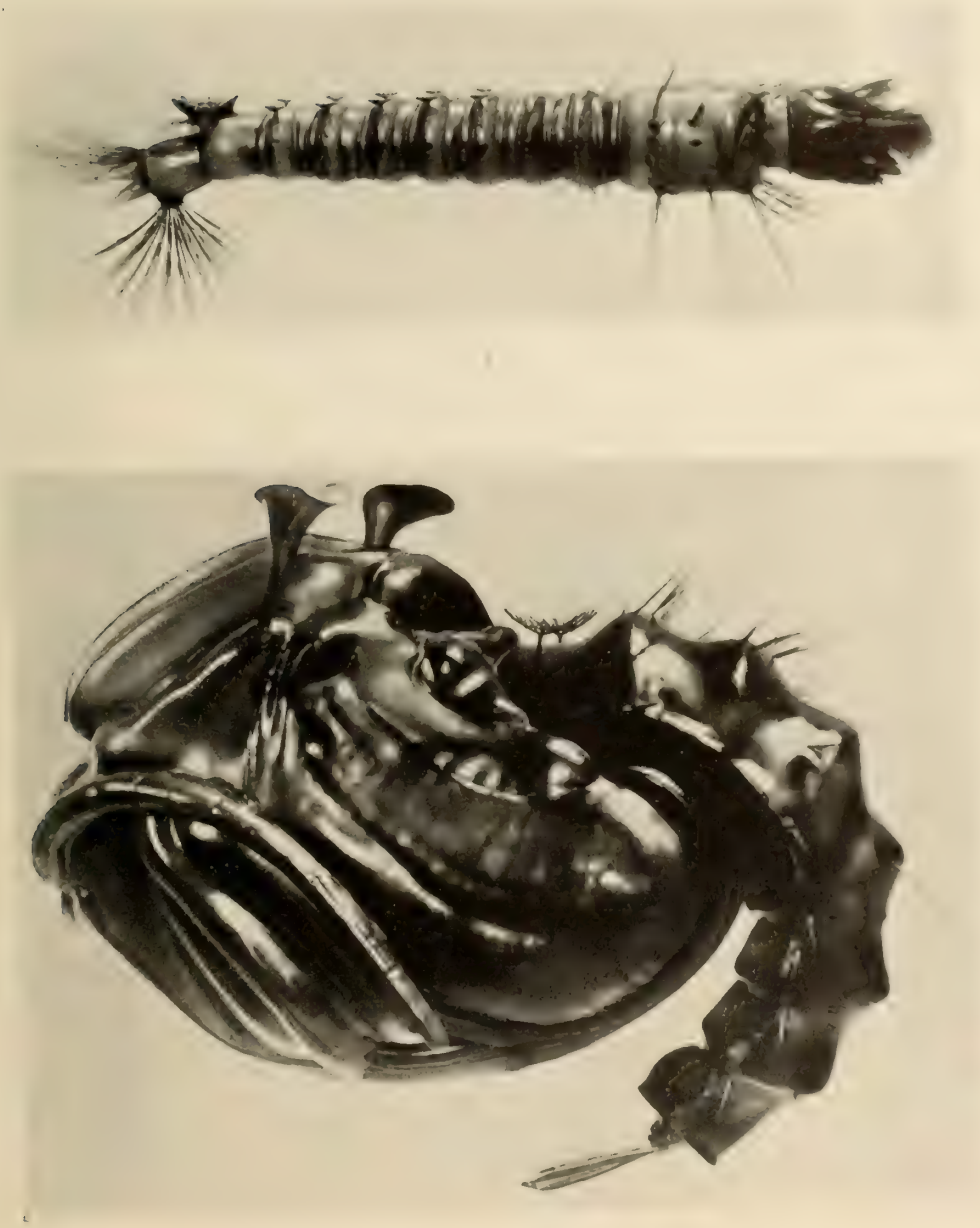


PLATE 1. — MODELS OF (ABOVE) A LARVA AND (BELOW) A PUPA OF A MALARIA MOSQUITO, *Anopheles*.

within this cyst and, after leaving it, move through the mosquito to its salivary glands. Six to fourteen days, the time depending on temperature and the kind of malaria, are required for the parasite to accomplish these changes and to move from the mosquito's stomach to its salivary glands. Until this is done the mosquito is not infective; but, after the sporozoites reach the mosquito's salivary glands, they, or at least some of them, will enter the human blood stream when the mosquito pierces a person's skin to feed. These sporozoites then change into the asexual forms living in human red blood cells; and the unfortunate human has malaria.

It will be noted that mosquitoes are more than mere carriers of malaria; they are parasitized by the malarial organism just as truly as humans are. Were it not for man, mosquitoes would not have malaria; and, were it not for mosquitoes that are subject to malarial infection, man would not have malaria. Malaria can not be naturally transmitted from one person to another except by way of certain kinds of mosquito; and bites of these kinds of mosquito will not give the bitten person malaria unless the mosquito itself has malaria.

For some unknown reason all or most of the sexual individuals in the red blood cells of a malarial patient break out of the cells at approximately the same time. It is then that the patient has the characteristic chill and fever, possibly because of poison released into the blood stream when the infected cells break. The time between attacks is characteristic of the kind of malarial parasite that is present. There are three chief kinds. *Plasmodium malariae* is the relatively rare quartan kind causing chills and fever that start every fourth day. *Plasmodium vivax* is the wide-spread and common tertian kind causing chills and fever that start every third day. *Plasmodium falciparum* is "aestivo-autumnal" or quotidian kind causing chills and fever that start every second day. The latter is also called "pernicious fever;" and the very dangerous "black-water fever" may be an extreme form of it.

A mosquito which has once had malaria may pass it on to numerous humans before it dies. James and Shute found that *Anopheles maculipennis* kept under laboratory conditions was infective for two and a half months after feeding on a malarial patient. One such mosquito could do a great deal of damage.

The mouth-parts of adult male mosquitoes are not well adapted for piercing and, so far as is known, no male mosquito ever "bites" humans. The antennae of adult male mosquitoes are decidedly feather-like; those of adult females are thread-like.

On each side of the proboscis there is a palpus, a segmented appendage that looks somewhat like an antenna. *Anopheles* females have palpi nearly or quite as long as the proboscis. In the United States most of the *Anopheles* have spotted wings. Furthermore, when resting, a female *Anopheles* usually stands with proboscis and body in a straight line at an angle to (not parallel with) the surface on which it is. If you see such a mos-



PLATE 2. — A MODEL OF A FEMALE MALARIA MOSQUITO, *Anopheles*.

quito, you may not be seeing a malaria-carrier but it is well to be suspicious of it and to act accordingly.

Contrary to common belief, a mosquito need not have a meal of blood before it can lay eggs. Many suck only plant juices, if, indeed, they feed at all. Even the blood-suckers often attack man less than they do other animals. An examination of the stomach contents of a large number of *Anopheles quadrimaculatus* in Louisiana showed that the stomach of only 4.3% of the individuals contained human blood and 95.7% of the individuals contained the blood of domestic animals. However, *A. quadrimaculatus* is one of the important carriers of human malaria. At least some species of mosquito may have races characterized by food preference, one of the races preferring human blood, another cow blood, and so on.

When mosquitoes pierce the skin to suck blood they usually inject a bit of fluid that is very irritating to some people but that may not greatly affect others. Apparently it is possible to acquire at least a partial immunity to this irritation; and possibly it is true that mosquitoes do not bite some people as freely as they bite others.

The duration of the life of adult female mosquitoes varies from a few weeks to six months or more, depending on the species and other factors. Males are relatively short-lived. Some species hibernate in the adult stage.

The immature stages of all mosquitoes are aquatic. The eggs are usually laid on the surface of water but in some cases they are laid on the damp ground of a depression where there will be a pool when rain comes. Some species, such as the common "rain-barrel mosquito," *Culex pipiens*, lays the eggs in compact masses and each mass may contain up to several hundred eggs. Most species, including those of *Anopheles*, lay their eggs singly or in loose clusters. An egg of *Anopheles* may be recognized by its having a "float" on each side.



FIGURE 1. — RESTING POSITIONS OF LARVAE OF (LEFT) ANOPHELINE AND (RIGHT) CULICINE MOSQUITOES.

The larvae of mosquitoes move through the water with a lashing, twisting motion that has earned for them the name "wrigglers." Each has a "breathing tube" at the hind end of the body. When in need of air, the larva comes to the surface of the

water and pushes the tip of this tube into the air. Tracheae carry air to all parts of the larva's body. The breathing tube of *Anopheles* is relatively short and the *Anopheles* larvae when resting at the surface of the water are parallel to the surface. *Anopheles* larvae feed chiefly at the surface, eating microscopic bits of organic matter. The larvae of most other mosquitoes rest at an angle to the surface and largely feed on organic matter on the bottom of the water.

It is not unusual for larval life to be completed in a week or ten days, although some species spend the winter as larvae. Mosquito pupae are active but they do not feed. Their shape somewhat suggests a seed. The slender abdomen, folded against the thorax, serves as a paddle when the pupa moves. Instead of having a breathing tube at the end of the abdomen the pupa has a pair of trumpet-shaped tubes on top of the thorax. Pupal life is usually very short, in some cases only a day or two.

Since mosquitoes breed in water and, hence, are common in swampy districts, malaria is most common in such districts. Also, since adult *Anopheles* are most active at night, people who are frequently outdoors at night are most likely to get malaria. The old idea that malaria is caused by night air of the swamps was a natural error. Now that we know the facts, we know that infection can be prevented by avoiding the bites of malarial mosquitoes. The best method of doing this is to get rid of the mosquitoes.

Of course, the most thorough-going method of getting rid of mosquitoes is to get rid of all water in which they might breed. This is not usually entirely feasible.

Some species breed in the water in artificial containers such as cisterns, rain barrels, and empty tin cans. Cistern and rain barrels can be fitted with mosquito-proof covers. Discarded cans and the like should be buried or otherwise made incapable of holding water. Some species breed in water in the hollows of partially decayed trees; but these are rarely troublesome. If they are, drainage holes can be cut in the trees or the hollows can be filled with cement or even dirt.

Depressions containing small pools, even temporary ones, should be filled or drained. The proper drainage of swamps usually requires the cooperation of trained entomologists and engineers. Improperly constructed or clogged drainage ditches may themselves become breeding areas, particularly for *Anopheles*.

Mosquito larvae and pupae are eaten by a large number of aquatic insects, including even the larvae of some mosquitoes (*Psorophora* and *Megarhinus*). They have still other natural enemies but the most efficient natural enemies of mosquito eggs, larvae, and pupae are certain fish. Goldfish are very useful in the control of mosquitoes breeding in fountain basins and ponds kept for ornamental purposes. Top minnows, such as *Gambusia*, are recommended for anti-mosquito work, especially in the control of *Anopheles* and other mosquitoes having top-feeding larvae. Most small fish eat mosquito eggs,

larvae and pupae. In order to get the most help from fish the banks of the ditch, pond or stream should be kept clear of weeds and the edges should be sharp and free from overhangs.

If water in which mosquitoes would breed can not be eliminated and breeding can not be controlled by fish, then oil or poison must be used. Practically every kind of mosquito larva must get air by pushing the end of its breathing tube through the surface of the water and into the atmosphere. If there is a sufficient film of oil on the water, the larvae come in contact with it when they come to the surface to breath. The oil has a toxic action and it is also possible that the delicate openings into the tracheae may be clogged with the oil. Ordinary kerosene can be used for this purpose but it is expensive and evaporates rather quickly. Light fuel oils are more generally used, and sometimes pyrethrum and other insecticides are added. Oiling is of little value on running water.

Paris green, a stomach poison, has been used with success against some mosquitoes. One part of Paris green mixed with 100 parts of fine dust (ordinary dry earth) and scattered on the surface of pools or ponds at the rate of 2 ounces of the mixture to 100 square feet of surface will kill most of the *Anopheles* and other surface-feeding larvae. It is said that so little Paris green does not injure cattle that may drink the water. To kill bottom-feeding mosquito larvae the poison may be mixed with wet sand so that it will sink when scattered on the breeding areas. Not all lots of Paris green are equally effective. Samples should be tested before much is used.

Incidentally, before using either oil or other material, it would be well to ask the federal Bureau of Entomology (U. S. Department of Agriculture) or your State Entomologist for more detailed and up-to-date information than is given here.

There is no efficient method of large-scale destruction of adult mosquitoes. The advertised "traps" that electrocute insects that come to lights often do much more harm than good because they kill so many insects that are beneficial to man and so few that injure him.

The mosquitoes in a closed room may be stupefied by fumigating with burning pyrethrum powder but they must then be swept up and killed. More deadly fumigation would scarcely be attempted except in extreme cases. Thoroughly screening the house so that mosquitoes can not get into the room is a much better plan. Screen with 18 meshes to an inch is better than the more common 16-mesh kind.

The important fact that in these days of high-speed, long-distance transportation the whole world must be watched for danger from disease-carrying insects is well illustrated by the invasion of Brazil by *Anopheles gambiae* from Dakar. The essential facts are contained in the following extracts from the "Reviews" for 1938, 1939, 1940 and 1941 of the Rockefeller Foundation by its president, Raymond B. Fosdick.

1938

"If Orson Welles, in his now famous broadcast of October 30, 1938, had announced not that the Martians had landed in New Jersey, but that a mosquito called *Anopheles gambiae*, a native of Africa, had arrived on the American continent, there would have been no public alarm. Indeed it is doubtful if there would have been any public interest. But *Anopheles gambiae* is potentially a much more dangerous invader than the Martians would have been. H. G. Wells's Martians, it will be remembered, were unable to adjust themselves to life on this planet and quickly died. *Anopheles gambiae*, striking from Equatorial Africa, has invaded South America and is making itself very much at home in Brazil.

"Who is this new invader of the Western Hemisphere and how did it get here? *Anopheles* mosquitoes are malaria carriers; the *Anopheles gambiae* is the most dangerous member of a dangerous family. Although the species has hitherto been reported from Algeria and Morocco, and from Southern Arabia as well, its principal home is the African tropical belt, extending from the southern border of the Sahara Desert south to the Zambesi River. It is the scourge of Central Africa, a carrier of a serious and often fatal type of malaria, sometimes complicated by the so-called 'blackwater' fever. Until 1930 this species of mosquito was not known on this side of the Atlantic. In that year, however, or shortly before, it crossed the ocean, apparently by airplane or on one of the fast French destroyers which at that time were working in connection with the French air lines between Dakar in West Africa and Natal in Brazil. The species was first discovered in 1930 within the city limits of Natal by Dr. Raymond C. Shannon, a member of the Foundation's staff, during a routine mosquito survey in connection with the yellow fever service. The seriousness of its presence was immediately recognized, but it was hoped that the invasion might be localized by natural conditions unfriendly to the invader.

"These hopes were disappointed. In 1930 and 1931 there occurred in the vicinity of the breeding area in Natal an outbreak of malaria of a severity unprecedented in the annals of the city. The yellow fever service was compelled to undertake gambiae control in order to maintain an efficient staff for its own work. By 1931, following prevailing winds, gambiae mosquitoes had traveled up the coast 115 miles. Two years of severe dry seasons seemed to check the invasion, and then, with the recurrence of normal rainfall, the onward flight started again.

"In recent years, severe epidemics of gambiae-carried malaria have occurred in localities over two hundred miles west and north of Natal. In the Jaguaribe Valley of the State of Ceará alone there were over fifty thousand cases of malaria in 1938. Over 90 per cent of the population was affected, with mortality in certain districts estimated at 10 per cent. So disabling and widespread was the epidemic that in some parts, crops were not planted and salt production was greatly reduced because of lack of labor. It is estimated that as a result of the ravages of this mosquito nearly every person in these affected areas will be on government relief in 1939.

"George E. Vincent, formerly President of the Foundation, in his report for 1928 wrote, 'It has been said that a good malaria fighter must "learn to think like a mosquito." He must ask: Which of many kinds of anopheline mosquitoes shall I try to imagine myself? How far is it possible to fly? When and where is food to be had? Which blood is to be preferred, human or animal? How can one get into a screened house? Where shall one rest after a good meal? Where is the best place to deposit eggs? Is the water of the right kind and temperature? Is it stagnant or flowing? Is there vegetable growth to protect eggs and larvae from fish?' Fortunately, through the work of the Foundation's staff and others in Africa, much is known about the gambiae. It breeds prolifically and rapidly, requiring only seven or eight days to develop from egg to adult, a fact that makes breeding possible in very temporary water collections. It has variable breeding habits, but seems to prefer stagnant, sunlit water. It has a high infection rate. During the outbreak in the city of Natal in 1930, 62.8 per cent of 172 specimens of gambiae caught and dissected were found to be infected with malaria, a rate higher than anything hitherto known in the Americas. The gambiae seems to prefer human to animal blood; of over a thou-

sand specimens tested in 1931, 82.3 per cent contained human blood. It is a domesticated insect; it usually bites indoors, not outdoors. Fairly reliable flight records show a distance of over three miles.

"Late in 1938 representatives of the Brazilian health service and of the Foundation staff investigated the infected area in North Brazil. They visited São Gonçalo and Baixa Verde, both of which have had heavy outbreaks of malaria following the introduction of gambiae to the region; and the lakes about Assú. They also went up the Jaguaribe River through Jaguaribe Mirim, Ouro Branco and Icó, to Lavras. This visit confirmed the seriousness of the situation. Once the gambiae gets into a river valley it spreads up the valley unless blocked at some point by natural or artificial barriers.

"With the assistance of The Rockefeller Foundation an anti-gambiae service is now being organized. Except for the distribution of quinine by field personnel working in infested districts, this service will not have the responsibility for medical care of the sick in dispensaries or otherwise. Inasmuch as there is insufficient time to develop a separate agency, it will be organized as a part of the existing local yellow fever service. This affiliation will make possible the utilization of the wide experience of the yellow fever service in the infested area and will provide a group of trained men accustomed to working under discipline. It is hoped by this method to confine the gambiae to the relatively arid areas which it now occupies, and possibly even to exterminate it there. If the gambiae should break through to the well-watered Parnahyba and Sao Francisco River Valleys, it is feared that it would be impossible to prevent its spread to a large part of South, Central and perhaps even North America. The Parnahyba Valley is 500 miles from Natal; the gambiae mosquitoes are already nearly half way there.

"In 1938 the International Health Division of the Foundation set aside $100,000 for expenditure in 1939 on the problem of the gambiae in Brazil. The Government of Brazil has also earmarked substantial sums. Funds will be released for control measures as soon as the plans of attack are drawn."

1939

"Many public health workers throughout the Americas are awaiting with anxiety the outcome of the campaign that has been organized against this mosquito. These workers realize that one of the most serious health problems facing their own countries is involved in the possibility of gambiae continuing its invasion and sooner or later reaching their territories. The tragic result of such a spread cannot be over-stated. A distinquished malariologist, Dr. M. A. Barber, has recently said: 'This invasion of gambiae threatens the Americas with a catastrophe in comparison with which ordinary pestilence, conflagration and even war are but small and temporary calamities. Gambiae literally enters into the very veins of a country and may remain to plague it for centuries. Even the penetration of yellow fever into the Orient might be a lesser evil, because its vector is domestic and more easily controlled.' . . .

"The actual field service of the campaign against the gambiae is being carried on by the personnel of the Foundation in collaboration with the Brazilian government. The Foundation has assumed the responsibility of direction and administration. Early in 1939 the Malaria Service of the Northeast (of Brazil) was created by government decree and began the task of organizing a field force to prevent further extension of the gambiae, to minimize the effects of its activity in the area already infested and to reduce its range.

"The first results in 1939 were frankly disappointing. The organization of the Malaria Service of the Northeast coincided with the beginning of the rainy season, when the gambiae advances by leaps and bounds, and this, together with the lack of personnel trained in methods of mosquito control, prevented any early apparent results of the campaign. As was anticipated, widespread epidemics of malaria occurred, and during the first few months of the Service some 114,000 persons were treated for the disease. During these early months the only visible consequence of activity was the reduction of mortality from malaria through medication of acute cases.

"By the beginning of July, however, a staff of over two thousand doctors, technicians, scouts, inspectors, guards and laborers, trained

in methods of control, was available, and even though the rainy season was unusually prolonged, appreciable results were obtained, not only in minimizing the further spread of gambiae in the frontier districts, but also in reducing the incidence of the mosquito in certain heavily infested sections to a point where careful surveys repeatedly failed to reveal the presence of either larvae or adults.

"In this campaign both climate and physical geography promise to be indispensable allies. The rainy season is restricted to 4 months out of 12, i.e., from February through May, and gambiae is a mosquito which breeds mainly in residual rain-water pools, shallow, open to the sun and without vegetation. It does not lay its eggs in permanent or deep water, in running, salty or shaded water or in water supporting aquatic vegetation. On the other hand, it takes advantage of every little depression in the ground, such as wheel tracks or hoofprints, no matter how shallow or small, which can present a water surface for eight or nine days. During the rainy season, with its almost daily showers, gambiae becomes a formidable antagonist. But for eight months in the year, the heat of the tropical sun, the strong continuous trade winds, and the low humidity combine to dry up all shallow surface waters and to make life precarious and of short duration for the gambiae. Potential breeding places are reduced to disconnected pools in the beds of the larger rivers, none of which maintains a flow in summer. Most of the higher rolling country back from the coast is practically non-infectible by gambiae. Its arid, stony soil supports a scrub vegetation composed of a resistant, thorny bush mingled with cactus. The region is without water for larvae, and without shelter for gambiae adults. The sparse population of the interior is therefore closely bound to the river systems and so also is the gambiae mosquito throughout the summer.

"The plans of the campaign against gambiae sound like the plans of an army on defense. The frontiers of the infested region are defined by fumigation posts on all the outgoing roads. These are the forts of this new kind of Maginot Line. A 10-mile zone beyond the gambiae's farthest limit of advance is to be kept non-infectible, which from the mosquito's point of view is the 'scorched earth' policy. Within this zone, as well as within the area already infected, all breeding places of the mosquito must be eliminated or treated with Paris green or other larvicide. The whole region is being mapped from the air so that no pools, ponds or other collections of water will be overlooked. The adult mosquitoes are being sought and killed in the houses with insecticide sprays to diminish the chances of their laying eggs and thus perpetuating the species in the region. Every automobile and train that leaves the infested area is being stopped, inspected and fumigated. A maritime service has been organized at points along the coast to disinfect every boat or plane bound for clean ports. It is war in a very real and grim sense, and, unlike other types of war, its purpose is the preservation of human life.

" . . . by December, 1939, gambiae had been pushed back to its central strongholds in the main river valleys and on the narrow coastal shelf. If the mosquito can be held within its present limits during the wet season of 1940, we can begin to think of the possibility of its eventual eradication from the entire region. This, of course, would mean extermination of the last surviving pair. It must be admitted that eradication is a rash word in terms of prophecy. As in all campaigns, accidents may determine the issue. Thus in one case the gambiae mosquito was transported many miles into previously uninfested territory through the medium of an old automobile which used an improvised wagon road through the jungle and thus avoided the fumigation post on the main thoroughfare. In another case it was a small fishing boat that carried the mosquito up the coast, thus driving a wedge in the defense line against the spread of the disease. If the war is won, victory will come through continued vigilance. The wet season of 1940 will test the efficacy of the present measures and will be critical as far as the gambiae campaign is concerned."

1940

"A year ago we reported that the gambiae had been pushed back to its central strongholds in the main river valleys and on the narrow coastal shelf of Northeastern Brazil — an area of perhaps twelve thousand square

miles. Around this area a line of fumigation posts was erected to keep the mosquito from breaking through into new territory, and a concerted advance was begun to narrow still further the boundaries of its domain. The weapons employed were Paris green for potential breeding places and spray insecticides for the fumigation of all buildings.

"This intensive campaign in 1940 had dramatic results. During the critical wet season the gambiae was pushed back on all sides, so that by the beginning of the dry season it had been practically restricted to the lower Jaguaribe Valley. This made possible the concentration in this area of a large number of workers for the final onslaught beginning in July. It can now be reported that no larvae or adults of gambiae have been found in the lower Jaguaribe Valley since the first week in September. A small additional focus lying some sixty kilometers beyond the known infested area was discovered in October, but it yielded readily to attack and was apparently clean by the middle of November. No evidence of gambiae in Brazil was found during the last forty-seven days of 1940.

"Further relevant evidence lies in the fact that in areas of earlier infestation where control measures have been progressively discontinued gambiae have not been found, even during the rainy season when the Brazilian type of anophelines flourish. In the Icó field laboratory alone, routine microscopic examination of some two million anopheline larvae, collected during the last eight months of 1940 in areas where control measures had been suspended, failed to reveal any evidence of surviving gambiae infestation. Considering the fact that the gambiae mosquito is a domestic insect with marked preference for certain types of readily observed breeding places, the failure to find either larvae or adults in an area in which no control measures are being applied seems highly significant.

"Those directing the campaign no longer consider it rash to speak of the eradication of gambiae from Brazil, although it must be remembered that the struggle will not be won until the last fertilized female gambiae on this side of the Atlantic is destroyed. In any case, no matter how many isolated foci may yet be uncovered, the critical phase of this immediate campaign seems to be over. Certain mopping-up operations remain to be done as the search is continued for infested areas. The number and extent of these areas should become rapidly apparent with the onset of the rainy season early in 1941."

1941

"A year ago we reported that it no longer seemed rash to speak of the eradication of gambiae from Brazil, although some mopping-up operations might be necessary if any areas became infested at the onset of the rainy season in 1941. It is a satisfaction to report that no such infested areas were discovered during the entire year. Except for a short period of two months in a small area in which infestation was first found in October 1940, no control measures were carried out during the year in the gambiae region, and a free opportunity was thus afforded for any remaining members of the species to increase their numbers at will. Thorough search by well-trained and selected personnel throughout the entire area of previous infestation, and even far beyond the old limits, failed to reveal the presence of a single gambiae.

"This particular battle would seem to have been won — at great labor and cost, and after enormous suffering. But the gambiae mosquitoes have apparently not given up their intention of establishing themselves in the Western Hemisphere. Airplanes are crossing the Southern Atlantic with increasing frequency, and commercial planes, of course, are now carefully fumigated, both after they leave Africa and again before their passengers are discharged in Brazil. A dead female gambiae was discovered after fumigation in a plane arriving in Brazil in October 1941, and two more in January 1942. The original infestation, with all its subsequent miseries, could readily have been started by a single fertilized female. Truly the price of liberty, as far as this malaria-carrying mosquito is concerned, is eternal vigilance."

YELLOW FEVER

Yellow fever, now known to be carried by mosquitoes, was for years one of the most dreaded diseases of the

American Tropics and western Africa. It occasionally extended its ravages into the United States. There were outbreaks in Boston in the seventeenth century and in New York as late as 1856, to mention only two northern localities that have been afflicted with it. New Orleans is in constant danger from it. Asiatic and Pacific regions have, as yet, been free of yellow fever; but, once introduced there, it might spread like a great conflagration.

Unlike malaria, yellow fever acts quickly. A patient either dies soon or recovers. If he recovers, he is usually immune to the disease for at least some years. The fact that during the attack the skin becomes yellow gave the disease its name.

It was formerly believed that yellow fever was spread by contact with a yellow fever patient, his excrements, his vomit, or even with any object that he had touched. As early as the middle of the last century, workers began to suspect that the disease is carried by mosquitoes. Starting about 1881, Dr. Carlos Finlay of Cuba, upheld the suggestion that mosquitoes are the carriers. Working by observation and experiment he had all but proved his case when in 1900 the U. S. Army in Cuba organized a commission to study the infectious diseases there.

The United States commission consisted of Dr. Walter Reed (its head), Dr. James Carroll, Dr. Jesse W. Lazear, and Dr. Aristides Agramonte. They soon abundantly proved that yellow fever is transmitted by a mosquito that was then called *Stegomyia fasciata*, now known as *Aedes aegypti*. They also demonstrated that it is not spread by contact with a yellow fever patient, his excrements or vomit. Volunteers, protected from mosquitoes, lived with yellow fever patients and even slept in beds soiled by the patients without acquiring the disease. Other volunteers, living in clean surroundings apart from yellow fever patients, allowed themselves to be bitten by infected *Aedes aegypti*. These volunteers developed the disease provided the mosquito had some days before sucked the blood of a yellow fever patient.

Dr. Lazear was accidentally bitten by such a mosquito while working in a hospital ward and died of the fever.

There has been much discussion concerning the identity of the organism that causes yellow fever. Whatever it is, it is exceedingly small, so small that it passes through the pores of bacterial filters with the "filterable viruses." Riley and Johannsen (1938, "Medical Entomology") say: "Noguchi in a series of papers presented seemingly definite evidence that the disease was due to a spirochaete which he named *Leptospira icteroides*, but his work met with much criticism, and he himself, before his tragic death in West Africa, came to recognize that he had probably been dealing with a mixed infection or an incorrectly diagnosed case of infectious jaundice and its organism *L. icterohaemorrhagie*."

Although it is now known that mosquitoes of other species, even of other genera, can and do transmit yellow fever, *Aedes aegypti* is directly responsible for most of the trouble in cities.

It is a "domestic" species, breeding in cisterns, water buckets, flower vases and similar containers. Development from egg to adult takes about two weeks at ordinary tropical temperatures. The adult may live for at least five months.

The success of fighting yellow fever in densely populated areas by fighting *Aedes aegypti* was shown by the results in Cuba, in the 1905 outbreak in New Orleans, and in the building of the Panama Canal. However, a new phase of the battle against yellow fever developed. Its history may be told by again quoting extracts from the "Reviews" of the Rockefeller Foundation.

1937

"In the *Review* of a year ago, mention was made of the fact that the epidemiological strategy of the battle with yellow fever had been badly upset by the discovery of the existence of the disease in jungle districts where there were no *Aedes aegypti* mosquitoes. It had previously been assumed that this mosquito was the only carrier and that man was the only natural host. The new picture of yellow fever, therefore, proved to be far darker than had been supposed. It is now known that vast areas of the hinterland of both South America and Africa are endemic centers of the disease. By what vector it travels, other than the *Aedes aegypti* mosquito, or what other hosts there are except man, is not known."

1938

" . . . Clinically, pathologically and immunologically, it has so far been impossible to differentiate jungle yellow fever from the classical aegypti-transmitted variety. Strains of virus isolated from jungle cases differ no more from strains isolated from urban cases than do these latter from each other. Jungle strains can be transmitted in the laboratory by *Aedes aegypti* just as the urban strains can be transmitted by various species of jungle mosquitoes found in Africa and by others found in South America.

" . . . Were it not for the existence of the jungle infection, yellow fever might have disappeared permanently from the Americas in 1934. . . .

"While vaccination promises to be of great aid in preventing the transfer of yellow fever by the human host from one locality to another, it cannot of course eliminate the virus in the jungle nor block its dissemination through contiguous forests in the tropics. Lurking somewhere in these forests are unknown vectors and other hosts than man; and a great deal of work remains to be done before they can be accurately identified."

1939

" . . . Blood tests of wild monkeys show that they are involved in epidemics, but other animals may also play a part. The capture and analysis of thousands of forest mosquitoes during an epidemic showed that three species had yellow fever virus in them, and that two of them could transmit the disease to monkeys by biting. This so-called 'jungle' yellow fever constitutes what may be a permanent reservoir of infection, and vast areas of the South American hinterland are undoubtedly endemic centers of the disease.

"Consequently The Rockefeller Foundation in recent years has shifted its emphasis from temporary anti-aegypti mosquito campaigns in a few of the larger centers to a broader program which includes three principal points:

"1. The permanent prevention of aegypti-transmitted yellow fever through more rigid control measures in urban areas.

"2. The early discovery of such outbreaks of yellow fever as may occur.

"3. The prevention of jungle yellow fever, in so far as possible, through mass vaccination of exposed populations."

1940

" . . . The work of the Foundation in Colombia, South America, in 1940, has thrown new light on this puzzling situation. . . .

" . . . the presence of yellow fever virus was demonstrated in two species of mosquitoes — the *sabethine* [*Sabethes* or *Sabethoides?*] and the *haemagogus* [*Haemagogus*]. In spite of repeated attempts to isolate the virus from many classes of insects, no virus was found in any form of insect life other than mosquitoes.

"The next step was to determine the susceptibility of jungle animals to yellow fever virus. For this purpose over two thousand wild animals were captured. It was found that while the yellow fever virus did not kill any of the animals tested and generally did not produce signs of illness, many species had virus circulating in the blood stream while the animals were running about — a condition especially favorable to the spread of the virus. The tests showed several broad groups of animals, comprising many species, to be susceptible. The chief groups are as follows:

Primates: man and monkeys.
Marsupials: the opossums, all species.
Edentates: anteaters, sloths, armadillos.
Rodents: agouti, paca, capybara, some species of mice.

. . .

"As a result of the several avenues of investigation followed in Colombia, the following tentative generalizations appear to be justified:

"1. Yellow fever is primarily a disease of jungle animals. The classical form involving transmission from man to man by the *Aedes aegypti* mosquito is more of a secondary cycle depending largely upon conditions of population concentration and mosquito breeding created by man himself.

"2. Transmission of jungle yellow fever appears to be by jungle mosquitoes from animal to animal.

"3. There is no animal reservoir of virus in the usual sense. Virus continues to circulate in the blood of susceptible animals for three or four days only, and does not subsequently reappear. Mosquitoes, however, once infected tend to harbor the virus for the remainder of their lives, which may be several months under favorable conditions. . . .

"The discovery that yellow fever can be transmitted in the jungle by carriers other than the *Aedes aegypti* mosquito does not minimize the significant part which the aegypti mosquito plays in the distribution of the disease among human beings. It is not too much to assert that if in urban areas this insect were brought under control as it has been in Brazil, the world could avoid the threat which in these days of fast transit might easily develop into a cataclysm in East Africa in India and even in the Orient, to say nothing of parts of the Americas, should the virus of yellow fever break through the barriers of quarantine, vaccination and medical vigilance."

1941

"Continued investigation of jungle yellow fever in Colombia brought added evidence that, in certain areas at least, a *Haemagogus* mosquito is the chief villain in the tragedy. One of the puzzling aspects of this problem has been the complete disappearance of this mosquito at certain periods, especially during the dry season, while at the same time the disease has continued among both animals and men. How could the disease be accounted for in those seasons when the vector supposedly responsible was not to be found? This problem was resolved by the discovery that *Haemagogus* is characteristically an inhabitant of the tree tops and may be found there when it is absent in catches made at ground level. The investigators were forced to develop techniques new to yellow fever work, and as one of them expressed it, it became necessary 'to associate with the monkeys in the interlacing branches high above the jungle floor.'

"With this knowledge available, it was possible to capture haemagogus mosquitoes throughout the entire dry season of 1941, and yellow fever virus was found repeatedly in the mosquitoes caught in the tree tops. An adequate mechanism was thus demonstrated for the carry-over of yellow fever virus from one rainy season to the next, and an explanation was afforded of the known frequency of jungle yellow fever among men engaged in felling trees."

DENGUE

This disease is also called breakbone fever because of the intense pains accompanying it. Fortunately it does not have a high fatality rate, although it is responsible for much suffering and loss of work. It occurs in the tropics and also in the southern parts of Asia, Europe and the United

States. It is carried by at least some of the mosquitoes of the genus *Aedes*, including *A. aegypti*, the urban yellow fever mosquito, and in the Philippines by *A. albopictus*. The disease organism is a filterable virus.

ENCEPHALITIS

Under this heading are included a number of closely related virus diseases that cause enormous losses to livestock each year and may cause outbreaks among the human population. Western equine encephalitis has been known from Kansas and the West for more than fifty years as a disease of horses. St. Louis encephalitis also attacks horses. Eastern encephalitis is a disease of birds. Dr. Wm. A. Davis has shown that various species of *Aedes* are capable of transmitting these diseases and it is possible that certain species of *Culex* may transmit the St. Louis type. These diseases cause deterioration of the brain, the space it occupied being replaced by water. "Sleeping sickness" is the result. When humans contract the western forms of the disease, chances of recovery are rather good, but the eastern form is almost always fatal. Human outbreaks are sporadic and many years may elapse between them.

FILARIASIS

Wuchereria, also called *Filaria*, is a genus of parasitic nematode worms. *Wuchereria bancrofti* is one of the more important species. Its mature stages occur in the lymphatics of man. Embryos ("larvae," microfilariae) live in various of the visceral organs by day or when the patient is active; but at night or when the patient is resting they swarm, often in large numbers, in the peripheral blood stream. If a mosquito such as *Culex quinquefasciatus* sucks blood containing these embryos, the embryos make their way through the walls of the mosquito's body, where they grow and change their form. If at that time the mosquito bites a human, the worms that have reached the mosquito's labium ("lower lip") crawl out and make their way into the human. Their presence in man, especially in the lymphatic system, causes various disorders including enormous swellings of the legs, a condition that is called elephantiasis.

It is worth noting that Sir P. Manson's work on *Filaria* in 1878 was the first demonstration of a parasite being transferred from mosquitoes to man.

FLIES

Among the many species of two-winged insects (Diptera) that are popularly called "flies," *Musca domestica* is the one most often found in man's dwellings. It is *the* house fly. Because it frequently breeds in the excrement of man and other vertebrates, it has been called the filth fly; and because, under certain conditions, it plays an important part in the spread of typhoid and other intestinal diseases, it has been called the typhoid fly. With the pronounced decrease in the number of stables and cow-barns in towns and cities, and with the highly desirable increase of sanitary sewage disposal, the importance of this fly in normal times in North America and in much of Europe has greatly decreased. However, the house fly is a

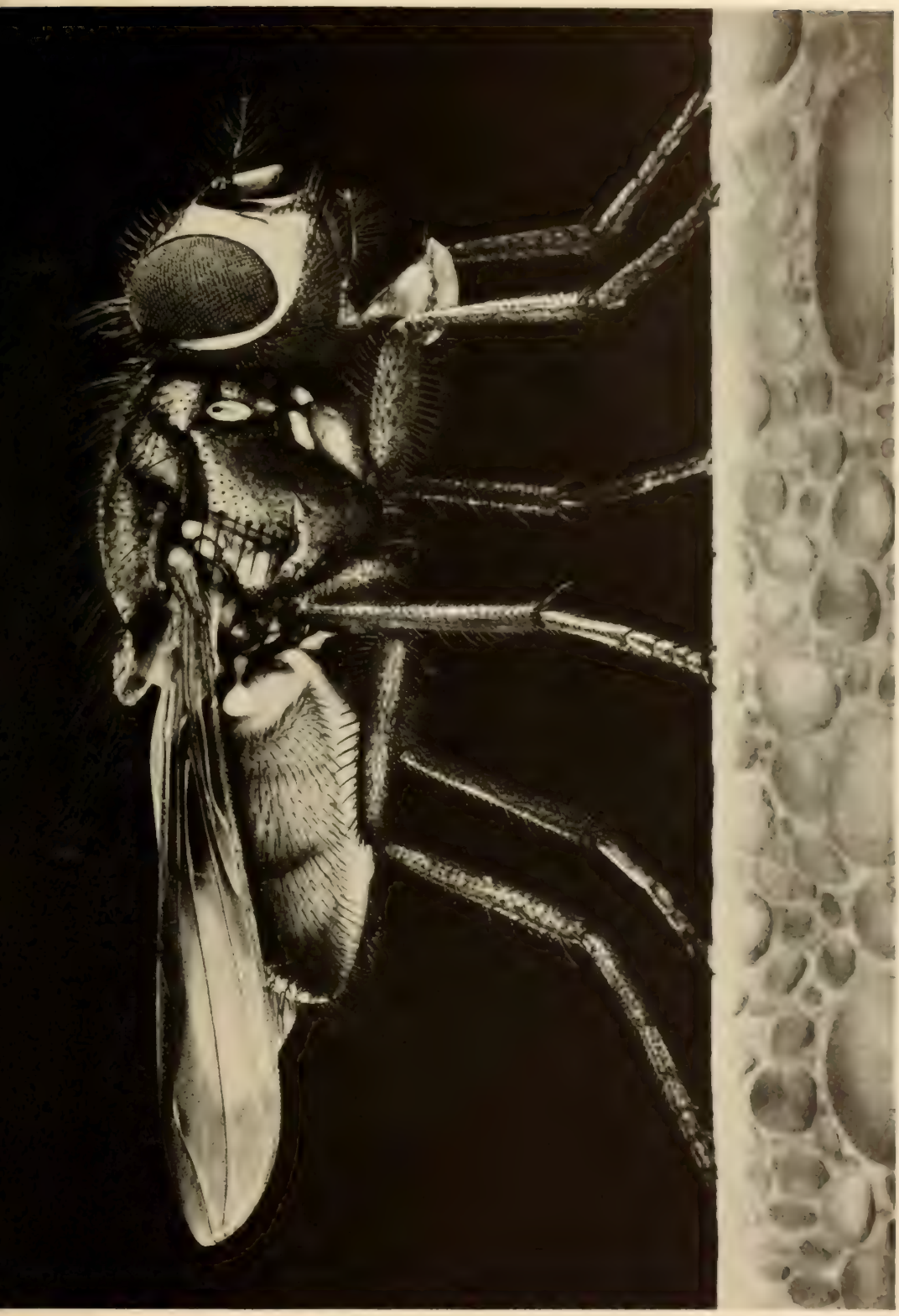


PLATE 3 — A Model of the House Fly *Musca domestica*

real menace wherever there is a relatively dense population of humans living in unsanitary conditions.

Musca domestica never "bites." The biting house fly, also called the stable fly, is *Stomoxys calcitrans*. It somewhat resembles *Musca* but, in addition to more technical distinctions, its beak is sharp-pointed in contrast with the flat-tipped proboscis of *Musca*.

Although horse manure, especially if it be mixed with straw, is the most favorable breeding place for *Musca*, it will successfully breed in any mass of fermenting organic matter. Each female may lay 1000 or more eggs. They hatch in a few hours if the weather be warm. Under conditions favorable to them the larvae (maggots) become full-grown in less than a week and the pupal stage lasts only about four days. Thus, development from egg to adult may be completed in about ten days. Using figures such as these, plus assumptions that no flies die and that favorable breeding conditions are unlimited, calculations are frequently made to determine how many descendants a single pair of flies would have in one season. Such calculations merely show how false the assumptions are.

Musca spreads disease in a mechanical way. An adult fly crawling on, for example, the excrement of a typhoid patient or of a "typhoid carrier" may get typhoid germs on its feet and then, crawling on human food, may leave such germs on the food by simple contact. Or, it may feed on typhoid-laden excrement and later regurgitate its food, germs and all, on our food. Since adults of *Musca domestica* have been found 13 miles from the place where they were marked and released, it is evident that they may be a large factor in the spread of typhoid and other intestinal diseases, including cholera. Adult flies may mechanically spread other diseases such as tuberculosis, anthrax, yaws (a tropical skin disease), trachoma, and possibly leprosy and poliomyelitis ("infantile paralysis"). As to poliomyelitis, *Stomoxys calcitrans* has been more frequently cited as a probable carrier but the question as to which, if either, is an important factor in the transmission of this disease is not yet settled.

As is the case with other injurious insects, the best control of *Musca* and *Stomoxys* is by preventing breeding and this usually requires community action. The proper treatment of manure piles and latrines is not easy. The best advice that can be given here is to secure detailed directions from your State Entomologist and from the Bureau of Entomology of the United States Department of Agriculture.

"Swatting" flies in the house and incidentally smearing their possibly disease-laden fluids on the walls and furniture is not very sanitary. "Sticky fly-paper" is much better. The various sprays may do little more than stupefy flies, after which they should be swept up and killed by burning or otherwise. Since these sprays may contain kerosene or some other inflammable substance such sprays should not be used near an open flame.

Glossina is a genus of blood-sucking flies occurring in Africa and Arabia. They are popularly called tsetse flies.

Unlike most "biting" insects, the males as well as the females suck blood. These flies somewhat resemble large house flies but they are more elongate and have longer wings which give them a parallel-sided appearance when at rest. The mouth parts somewhat resemble those of *Stomoxys calcitrans*. Another characteristic of these flies is that the larvae live in the mother's body. The larvae feed on maternal secretions until they are ready to pupate, at which time they leave their mother's body.

The thing that makes this genus important is that its members are carriers and intermediate hosts of protozoa of the genus *Trypanosoma*. *Trypanosoma brucei* is the organism causing nagana, a very serious disease of cattle and horses. *Trypanosoma gambiensis* is the cause of African sleeping sickness, an even more serious disease of man. The former is carried by *Glossina morsitans* and the latter by *Glossina palpalis* and *G. tachinoides*.

If these flies bite a person having *Trypanosoma gambiensis* in his blood and not more than a few hours later they bite a healthy person they will, by simple mechanical transfer, inoculate the second person. Possibly other biting flies and even mosquitoes do the same. This infectiveness disappears in a few hours but the parasites penetrate the intestinal walls of *Glossina*, and, after a complicated metamorphosis analogous to the transformation of the malarial parasites in a mosquito's body, are ready to enter human blood again.

A satisfactory control of *Glossina* has not yet been developed. Clearing the riverside forests where they live and burning the grass in open places is of local value. Screening of patients to prevent the flies from reaching them seems to have little effect. Possibly wild mammals are reservoirs of infection.

Flebotomus is a genus of minute, biting "sand flies." Although not common in the United States, they are widely distributed and often abundant in the tropics. In addition to the irritation caused by their bites, they are either suspected to be or proved to be carriers of such human diseases as three-day (papataci) fever, kala azar, tropical ulcer, Carrion's disease (Oroya fever or verruga peruviana) and leishmaniasis.

Many of the members of the family Ceratopogonidae, particularly the species of *Ceratopogon* and *Culicoides*, bite human beings. They were formerly included in the Chironomidae but the true midges do not bite although they resemble mosquitoes and are often mistaken for them. Two of the common names applied to the biting midges are punkies and no-see-ums. Their bite is very irritating and they are so small that it is difficult to see them in time to kill them before they bite. Their larvae are aquatic or live in decaying vegetation or between tide zones. It is not known that any of our native species carry disease but several species in the Cameroons are intermediate hosts of a filarial worm in its transfer from man to man.

In some places, species of Simuliidae, the "black flies," are a major pest.

They are active by day and attack both animals and man. Sometimes certain species occur in enormous numbers and bite severely. Since their larvae live in running water, artificial control is practically impossible. Our northern species probably do not spread disease, although certain tropical species of *Simulium* are known to be intermediate hosts of nematode worms living in nodules of the skin of man, causing the disease called onchocerciasis. If the nematode settles in eyes, blindness frequently results. Fortunately, this disease is at present limited to Mexico, Central America and tropical Africa.

The family Tabanidae contains many species variously known as horse flies, gad flies, deer flies and so on. Some species are quite large and none are really small. Only the females bite. It is known that at least one species, *Chrysops discalis,* may transmit tularaemia in a purely mechanical way. West African species *(Chrysops dimidiata* and *C. silacea)* are intermediate hosts of a filarial worm (*Filaria diurna*) causing the disease loa loa.

REPELLANTS FOR PROTECTION AGAINST BITING DIPTERA

Many lotions or ointments have been used to repel mosquitoes, midges and biting flies but none are completely satisfactory, even for a short time. Oil of citronella is an old standby; but many people do not like the odor and prefer the insect bites. "Staway" is a newly developed product that is practically odorless. It possibly affects rayons and should not be used in contact with these fabrics.

The following formula, developed and extensively tested by the Canadian Entomological Branch, is said to give excellent results.

Oil of thyme . . . . . ½ fluid ounce
Concentrated extract
of pyrethrum . . . . . 1 fluid ounce
Castor oil . . . . . 2 to 3 fluid ounces

In addition to the above almost any fly spray, and particularly those containing both rotenone and pyrethrum, will give considerable protection. Ordinary kerosene or coal oil will repel pests for some time but the effects are not lasting.

FLEAS

Fleas are notorious chiefly for their bite but some of them carry disease, particularly plague. Typhus also may be carried by fleas but it is more often associated with lice. The eggs of fleas are usually laid on the ground or drop to the ground from the animal on which they have been deposited. The larvae feed on organic debris, often in the cracks of floors or in the nests of the hosts. Pupation takes place there. Adult fleas may live more than two years. The fleas that consistently bite humans in the United States are the dog and cat fleas *(Ctenocephalides canis* and *felis)* and, of course, the human flea (*Pulex irritans*). Other fleas bite man occasionally but do not persist in their attacks.

BUBONIC PLAGUE

Justinian, who ruled the Eastern Roman Empire in the sixth century, is chiefly remembered for the laws that he instituted in the lands over which he ruled; but, despite the great good that he accomplished in bring-

ing justice to the conquered lands, the people suffered greatly from disease. It was during his rule that there was the first recorded great epidemic of bubonic plague. It started in Egypt in the year 542 and spread as far north as Constantinople. It lasted for more than fifty years and resulted in the death of an estimated 100,000,000 people.

The next great outbreak killed about one-fourth (25,000,000) of the population of Europe during the fourteenth century. About two hundred years later an epidemic of plague swept over Great Britain, where more than half of the population died from the disease, there being more than 70,000 deaths in London alone during the years of "The Black Death" (1664-1666). It has been suggested that some of the ancient epidemics of "plague" were typhus, not bubonic plague. The only large, recent epidemic of plague occurred in Manchuria in 1910-1911, resulting in the deaths of more than 60,000 persons; but every year there are numerous isolated cases or small epidemics in various parts of the world.

Bubonic plague seems to be primarily a disease of rats, squirrels, and other rodents. It is a bacterium, *Pasteurella pestis*. Simond showed in 1898 that it is spread from rodent to rodent by fleas. The form of the disease that occurs in rodents other than "domestic" rats and mice is called sylvatic plague. There are three different forms of the disease in man and recovery is frequent only from the form in which the disease is confined to swellings ("buboes") of the femoral and axillary glands. In a second form the bacteria develop in the blood stream, causing secondary pneumonia, which is transmitted from man to man as a result of inhaling droplets ejected by the coughing of a diseased person. A third form, the septicaemic or "fulminating," may develop rapidly from either the bubonic or the pneumonic plague. Death is almost certain to result from either of the last two.

Man may, at least occasionally, contract bubonic plague by contact with rodents that have the sylvatic form or that have recently died as a result of it. Possibly man may also contract the disease as the result of scratching into his skin excrement from some kinds of the fleas that have fed on diseased squirrels or other diseased rodents living in the open country. However, it seems unlikely that epidemics ever start in that way. The blood sucked by a flea and the bubonic bacteria that may be sucked up with the blood in most cases pass through the flea's intestine. The undigested portion of the blood and the bacteria are voided as feces but most kinds of fleas do not regurgitate from the mouth while feeding. This is not true of *Xenopsylla cheopis,* the flea that is often abundant on rats living in human habitations, especially in cities. If this flea feeds on the blood of a rat infected with the bubonic bacterium, a jelly-like mass may form in the flea's alimentary tract in front of the mid-intestine. This mass blocks the alimentary tract so that blood sucked by the flea can not pass into the intestine and be digested. As a consequence, the flea gets very hungry

and is continually trying to feed. Also, while the flea is feeding, the blood that it has just sucked, together with some of the blood from a former feeding, is regurgitated. If this flea with its alimentary tract thoroughly infected with bubonic bacteria regurgitates while feeding on a human, it will infect that person with the plague. When these three things come together—rats infected with the plague, the flea *Xenopsylla cheopis,* and large numbers of human beings—an epidemic of bubonic plague is almost certain to break out. If one of the three is absent, such an epidemic is unlikely and probably impossible. The best safeguard for us is to get rid of rats and other rodents around human habitations.

While rat fleas play the most important part in the dissemination of plague they are not the only carriers of the disease. In 1941, Wheeler, Douglas and Evans demonstrated that the sticktight flea *(Echidnophaga gallinacea)* also carries the disease. The sticktight flea is chiefly a pest of chickens but it also attacks other birds, cats, dogs, rodents, and occasionally man. Birds are not known to suffer from plague but the "sticktight" is found commonly on the burrowing owl and, since this bird is known to be associated with rodents in their burrows, it may play an important part in spreading the disease through the transportation of infected fleas.

THE CHIGOE FLEA

The names Chigoe, chigger (see mites), chique, jigger and sand flea are applied to a flea *(Tunga penetrans)* that has the very unpleasant habit of fastening itself to the human body and burrowing into the flesh. Its favorite places are along the side of or under the toe- or finger-nails, or between the toes; but they may attack any part of the body. It is a very small flea that, because of this habit, causes a great deal of misery to humans but it is not a disease carrier.

It is the female flea that does the damage. She attaches herself and, after feeding, bores under the skin, causing a painful sore or pustule. The eggs are laid while the female is embedded and may remain in the wound or drop to the ground. If they hatch in the wound, the larvae drop to the ground, where they develop in the same way as other fleas.

The Chigoe is found in subtropical and tropical America and Africa. When it infests buildings it may be destroyed by thorough spraying, dusting with poison, or fumigation. Those that have entered human flesh may be cut out and the wound cleaned and dressed; or the insects may be killed by the application of turpentine or other remedies, discharge taking place as a result of ulceration.

THE TRUE BUGS

A great many of the bugs (Hemiptera and Homoptera) will "bite" man occasionally but very few of them are human pests, the best-known being the bedbug. Many small bugs that normally feed on plants, such as leafhoppers and aphids, will quite often take a nip, but these are not blood-suckers and no after-effects result. Some of the larger bugs that prey



PLATE 4.—A MODEL OF THE RAT FLEA *Xenopsylla cheopis*

upon other insects may bite humans if handled carelessly. Only one group, the assassin bugs, is definitely associated with the spread of disease.

THE BEDBUG

There are three kinds of bedbugs that consistently attack man, the common one being *Cimex lectularius*. It is world-wide in its distribution. The other two are tropical or subtropical. (In addition to these, there are a few kinds that attack bats and birds and so closely resemble the ones attacking man that only an expert can distinguish them.)

There is no positive evidence that bedbugs carry disease in nature, but it has been demonstrated that they may do so under controlled laboratory conditions. The general opinion is that, while they are capable of carrying and spreading certain diseases, they do not do so normally and cannot be regarded as carriers.

Bedbugs require about two months to mature during warm weather and apparently do not breed during the cool months in temperate zones. Consequently, there are only two or three generations a year. The fact that bugs of all ages are found at the same time is due to the egg-laying habit, each female laying ten to fifty of her two to five hundred eggs every few days.

During the day bedbugs conceal themselves under folds in bed mattresses and in cracks and crevices in beds, walls and floors, coming out at night for a meal of human blood. When a light is turned on they scurry for cover. If food is scarce, they may travel from one apartment to another and even from one house to another. They are usually carried into the house on clothing or in travelling bags. Railroad coaches, street cars, busses, hotels, cloak rooms and friends' homes may be sources from which the bugs come.

Bedbugs may be controlled by thoroughly spraying crevices in the beds and rooms with odorless kerosene or coal oil. (Be careful of fire.) The efficiency of the spray is greatly increased by the addition of pyrethrum and rotenone.

CHAGAS' DISEASE

Chagas' disease is caused by a protozoan, *Trypanosoma cruzi*, and is transmitted from man to man by species of *Triatoma*, *Mestor* and *Rhodnius*, all members of the Assassin Bug family. These bugs are also known as kissing bugs and cone-noses, the latter because of the shape of the head. They comprise a group that has apparently changed from a predaceous, insectivorous habit to one of sucking vertebrate blood. Some related species that do not persistently suck blood may do so at times.

The trypanosome undergoes changes when swallowed by the bug; but the disease is apparently not transmitted by the bite of the insect. The insect usually defecates while or immediately after feeding. The trypanosomes in the insect's intestine are carried in the insect's excrement and may enter the body of man as a result of the person scratching or licking the sore caused by the bite of the bug.

Chagas' disease was originally recognized in Brazil in 1909, where it was quite prevalent, especially among

young children. It is frequently fatal. It has since been found in other tropical American countries and as far north as the southern United States.

In addition to spreading the disease, the insects may cause severe illness as a direct result of their bites. They apparently inject a specific poison that causes a burning sensation, intense itching and much swelling. In addition to the original focal swelling, red blotches may develop on various parts of the body. The effects may last for weeks, although they usually disappear within a few days. Bites from some of the species may cause nausea, palpitation of the heart, rapid breathing and other symptoms which are also evident in Chagas' disease but uninfected bites are not fatal.

A northern species of Assassin Bug that sometimes bites humans is the Masked Bedbug Hunter, the young of which are usually covered with dust. They feed on bedbugs but, as they feed also on other household insects, their presence does not necessarily mean that bedbugs are in the house.

LICE

True lice, not plant lice, are wingless insects of the order Anoplura, also called Siphunculata. They are probably related to the true bugs. All of them live on and suck the blood of mammals. The Head Louse of man (*Pediculus humanus* or *capitis*) may be the same species as his Body Louse (*Pediculus corporis* or *vestimenti*). The latter is also called Cootie and Gray-back. The Crab Louse of man is *Phthirius pubis*.

The control of lice attacking man may be accomplished by personal cleanliness; fumigation of living quarters, bedding and all clothing by chloropicrin ("tear gas") or some other effective fumigant; sterilization of clothing and bedding by steam or air at 140° for twenty minutes, or by ironing them slowly with a hot iron; use of mercuric chloride for destroying pubic lice; and use of kerosene for the killing of head lice. Since some louse-borne diseases can be transmitted by crushing infected lice between the fingers, this means of control is dangerous.

TYPHUS FEVER

Other names that have been applied to the disease that is now generally known as typhus fever are ship fever, jail fever, war fever, Brill's disease, tabardillo, murine disease and spotted fever. It should not be confused with typhoid fever. The disease organism is a bacterium, *Rickettsia prowazeki*. One of the symptoms of typhus is a blotching of the skin; but since similar spottings are caused by other diseases, the name "spotted fever" for typhus is confusing. The name "murine disease" alludes to the part that rats and mice have in the spread of typhus.

Rats and mice are subject to typhus. Apparently fleas, especially *Xenopsylla cheopis*, transmit the disease from rodent to rodent and also from rodent to man. Lice of the genus *Pediculus* are apparently the principal — possibly the only — carriers of typhus from man to man. The disease enters the human system either when an infected louse bites the person or when the feces of an infected louse or the crushed body of an infected louse is rubbed on a scratch

or other break in the skin of the person. After a louse has bitten a typhus patient a period of seven to eleven days must elapse before the crushed body of the louse can transmit the disease but it may be transmitted by the louse's feces after as few as three days. Development of the disease in humans requires ten or twelve days.

The disease is milder in children and an attack results in immunity, which may explain the apparently low incidence of the disease among peoples who are normally infested with lice. Outbreaks of typhus are common among soldiers and in concentration camps because the crowded and often unsanitary conditions in camps favor the increase of lice. The control of rats and of lice means the control of typhus. The recent development of a vaccine for innoculating against typhus may greatly reduce the danger of the spread of the disease.

TRENCH FEVER

Trench fever is carried by lice in the same way as is typhus fever but there is a great difference in its symptoms. There is no spotting of the skin; the disease may last for two or three months; and no immunity is produced. The onset of the fever after infection by crushed lice occurs in from five to twenty days; but if the infection occurs from the louse's excrement the fever develops in eight days. It is not known how much time must elapse after feeding upon a victim of trench fever before crushed lice can produce the disease in man but the feces are capable of doing so after five days.

Trench fever is not a dangerous disease, but it may be responsible for great loss of manpower. Those suffering from it often are very slow in regaining their strength and may be absent from duty for three or four months. It was only during the first world war, that the disease became well known and was studied by both British and American commissions established for that purpose. Almost all that we know about the disease is the result of the investigations of these commissions. It is impossible to determine the number of cases that occurred during the first world war because thousands of cases of influenza were diagnosed as P.U.O. (pyrexia of unknown origin) before it was discovered that two diseases were concerned. The name trench fever did not come into use until the disease itself became common.

EPIDEMIC RELAPSING FEVER

This type of relapsing fever is spread solely by lice, chiefly as a result of scratching by an individual who has crushed lice. The spirochaete causing the disease develops in the liquids and organs within the body-wall of the louse but is unable to survive long in the intestine. The disease is not common but is liable to appear in epidemic form. It is easily controlled by the elimination of lice.

TICKS AND THEIR RELATIVES

Insects never have more than three pairs of jointed legs; and the head of an insect is not immovably joined to the thorax. Scorpions, spiders, mites and ticks have four pairs of jointed legs (at least when adult) and the head is immovably joined to the thorax. Scorpions have a segmented abdomen. Spiders and mites, including ticks, have



PLATE 5. — A MODEL OF THE BODY LOUSE, *Pediculus corporis*

the abdomen unsegmented. Spiders have a definite constriction in front of the abdomen; ticks and other mites have the abdomen more broadly joined to the rest of the body. Ticks are classed as a superfamily (Ixodoidea) of the order (Acarina) of mites. The distinctions between ticks and the other mites are rather too technical to be given here.

TICKS

Ticks are parasitic on vertebrate animals, including man, and may prove to be among the most important carriers of diseases to man and domestic animals.

The life history of the various kinds of ticks follows the same general pattern but there is a very great difference in the time required to reach maturity. Some kinds complete their life cycle in less than a year, while others require up to four years. A single female may lay as many as 18,000 eggs; three or four thousand is a common number. Newly hatched ticks may live for about four months without feeding, and nymphs and adults may starve for more than a year. The six-legged larvae or "seed-ticks" hatch from eggs on the ground and attach themselves to some animal. Some kinds remain on the animal until mature but most of them, after feeding for from a few hours to a week or more, drop to the ground to molt. After molting they again attach themselves for feeding or they may hibernate. In all, there may be from three to eight molts (depending on the species) before the adult stage is reached. Attachment occurs primarily for the purpose of feeding; however, some kinds also mate on the host.

Ticks present a very different appearance before and after they have become engorged with blood. Before feeding, the tick is round or ovoid in outline and quite flat or a little convex above and concave below. Its legs are conspicuous. When it has become engorged it may be five or six times as long, the body is rounded, and the legs are relatively small. As the blood is digested the body becomes smaller.

"The best way to remove a tick, and this should be done without delay, is to take hold of it with the fingers and pull it off slowly with a firm straight pull without jerking" (Herms). If care is not used, the head may break off and remain in the wound.

ROCKY MOUNTAIN SPOTTED FEVER

Tick fever, black fever, blue disease and black measles are other names of this disease. It has been known in the Bitter Root Valley of Montana since 1872 but, despite its name, it is not restricted to the western mountain areas. In the East it is most prevalent in Maryland, Virginia, and North Carolina. Parker states that it is present in at least 39 states; and since 1931 it has been reported from 26 of the eastern and central states. The virulence of this fever varies greatly in different parts of the country. In southern Idaho the mortality is only 1% to 3% of the victims, in California about 16%, and in eastern Montana very much higher. The outbreak of a rash on the wrists, ankles and sometimes on the back, later spreading to all parts of the body, is one symptom and explains the descriptive name "black measles."

Proof that Rocky Mountain spotted

fever is carried by ticks was furnished by McCalla and Brenton in 1905, although Wilson and Chowning had advanced the theory three years earlier. Wolbach discovered the disease organism *(Rickettsia rickettsi)* in 1919 and named it in honor of Dr. Ricketts, whose work in connection with Rocky Mountain spotted fever and typhus was outstanding. Dr. Ricketts died from an infection during his researches on typhus in Mexico.

Rocky Mountain spotted fever occurs in rabbits and other rodents and is transmitted from rabbit to rabbit by the rabbit tick *(Haemaphysalis leporis-palustris)*. This tick does not bite man and therefore does not transmit the disease to humans. The ticks that do transmit the disease both from rodent to rodent and from rodent to man are (more or less in the order of their importance) the Rocky Mountain spotted fever tick *(Dermacentor andersoni)*, the American dog tick *(D. variabilis)*, the Pacific Coast tick *(D. occidentalis)*, and the brown dog tick *(Rhipicephalus sanguineus)*.

Ticks may become infected with *Rickettsia* during their first meal or during any future meal. Once infected, they are capable of transmitting the disease during their entire lifetime; and the females can even transmit the disease to their offspring through the eggs. Because the immature stages of ticks feed particularly on rodents, cats, dogs, etc., almost the whole source of human infection is the bites of adult ticks.

The disease passes the winter in ticks that are either in the adult or nymphal stage. Parker states that the bite of an infective, over-wintered tick in the early spring may not produce recognizable infections but may produce an immunizing attack of the disease. Later in the season bites become more dangerous, the disease becoming more severe as the result of warm weather. However, since the adults of *D. andersoni* dislike hot weather, they usually seek cover under grass by the first of July, after which time there is very little danger of being bitten by this species. In sections of the country where other species of ticks capable of transmitting the disease are active during the summer months, the danger of infection is present at all times.

Fortunately, an infected tick does not transmit the infection until it has fed on its "host" for from about two to ten or more hours. Consequently the danger of infection is slight if attached ticks are removed within a few hours. One usually becomes aware of a tick crawling on the body or trying to insert its mouthparts, but ticks may very often become attached without the knowledge of the victim and they may remain for a considerable time before they are detected. It is therefore advisable for those in tick-infested areas to examine themselves thoroughly on returning from the fields or woods. Oddly enough, it is usually men who acquire Rocky Mountain spotted fever in the West, where *D. andersoni* occurs; but it is usually women in the East where the dog tick is the vector.

General control measures against the Rocky Mountain spotted fever tick have not been satisfactory and the safe thing is to keep out of tick-infested areas during the dangerous part of

the year or to wear clothing that will make it difficult for the ticks to reach the body. A vaccine has been developed by the U. S. Public Health Service for protection against the fever. It gives protection for at least one season but it is less effective as the season progresses and the virulence of the *Rickettsia* increases.

TICK PARALYSIS

Tick paralysis is rather prevalent and there are numerous cases each year. It is rarely fatal to humans. As far as is known, it is caused only by the Rocky Mountain spotted fever tick and its occurrence therefore coincides with the distribution of *D. andersoni*. The exact cause of the paralysis is not known but it is believed to be due to a salivary secretion that is injected by the tick into the body of the person upon whom it is feeding.

Children seem to be particularly susceptible to tick paralysis. In one of the early cases reported in Oregon by Temple in 1912, the patient after retiring the preceding night in healthy condition was unable to stand in the morning, and by the third day the paralysis was so complete that the child was unable to speak or eat. The removal of two engorged ticks resulted in complete recovery within a week. After removal of the ticks the patient usually recovers fully within a day or two.

In most cases of the disease the engorged ticks have been discovered on the nape of the neck or along the spine, these being the favorite places of attachment for this species of tick. Recovery may take place naturally when the ticks drop off; but, on the other hand, death may result if a number are present and the paralysis is prolonged.

COLORADO TICK FEVER

This fever occurs in many parts of the Rocky Mountain region and results from the bite of the Rocky Mountain spotted fever tick *(Dermacentor andersoni)*. It is painful and debilitating, but not fatal. The disease organism is not known.

RELAPSING FEVER

Relapsing fever has been known in Africa for about a hundred years; but it was not until 1904 that Ross and Milne definitely showed that the disease is tick-borne. As early as 1857 David Livingston reported upon the evil effects following the bite of a tick that was later named *Ornithodoros moubata* by Murray (1877). It is said that the natives of Central Africa have long dreaded the bites of ticks.

The disease organisms of relapsing fever are various species of the bacterial genus *Spirochaeta*. Possibly they are merely forms of one species, *S. duttoni* or *S. recurrentis*. It occurs on all of the principal continents and, wherever found, is transmitted by ticks of the genus *Ornithodoros*. In the United States it is confined to the Southwest and to altitudes above 3000 feet in our western mountains, the regions occupied by *Ornithodoros turicata* and *O. hermsi* respectively. The natural "reservoirs" of relapsing fever in the United States are squirrels and other rodents.

When infected blood is taken into the body of a tick the Spirochaetae bore their way through the walls of the digestive tract and into apparently

all parts of the tick. Those that reach ovaries innoculate the eggs of the tick and the infection is passed on to the next generation. Some reach the tick's salivary glands and others the coxal glands (glands at the bases of the tick's legs). Those that reach the salivary glands are injected by the tick into the wound caused by its subsequent feeding. Probably those that reach the coxal glands may enter the human body through a break in the skin. There is a case on record in which a man contracted the disease directly from a squirrel by accidentally smearing his fingers with its blood.

TULARAEMIA

This is primarily a disease of rabbits but it has been found in other wild animals, including coyotes, sheep and quail. It severely attacks man also. The disease organism is a bacterium, *Pasteurella tularensis*. It is widely distributed in the United States. The rabbit tick, *Haemaphysalis leporis-palustris,* is largely responsible for its distribution from rabbit to rabbit, although the rabbit louse, *Haemodipsus ventricosus,* also is a vector. Probably transmission of the disease occurs whenever blood from an infected animal is transferred to a susceptible one, including man. When the disease was first recognized in 1919 it was called deer fly fever because it was found to follow the bite of a species of deer fly, *Chrysops discalis*. People who shoot rabbits or prepare them for cooking are in danger of becoming infected by the blood of diseased ones coming in contact with a scratch or other break in the person's skin.

OTHER MITES

Many kinds of mites other than ticks may occasionally bite human beings, but only a few kinds consistently attack man. Although not carrying a disease, some of them may be considered to be themselves a disease.

SCABIES

This disease, also called mange and itch, is a very small, almost colorless mite, *Sarcoptes scabiei,* that bores under the skin, particularly where it is delicate, making tunnels that may exceed an inch in length. Since the life cycle is completed in about two weeks and each female lays fifteen or twenty eggs, a single female gaining entrance under the skin is soon responsible for an extensive sore, the skin becoming irritated by poisons given off by the mites. Scratching results in bleeding and often increases the irritation. In addition, scratching may spread the mites to other parts of the body.

This mite occurs also on swine, horses, cattle, dogs, and probably on other mammals. Outbreaks on man can often be traced to some individual who has been in contact with mangy domestic animals. In peace time its presence on man is usually of local distribution, although whole families or school districts may be affected. During war, when people may be crowded together unduly, it may become very prevalent and movements of infested people may carry it into districts that were formerly free from it.

The treatment now recommended in England, where extensive tests have been conducted because of the great menace of infestation during war con-

ditions, is 18% of sulphur incorporated in a bland soap and applied to the body in a lather that is allowed to dry. About three applications in four days often results in a complete cure. The British distribute the medication in what they call "sulphur lather tablets." Although these tablets are not currently available in the United States, the treatment was originally developed here by Dr. R. A. Nolan.

CHIGGERS

Harvest mites, red bugs, or chiggers are often the cause of much suffering by those who find it necessary to be in the fields during the summer and autumn. These mites should not be confused with the Chigoe flea, sometimes called chigger.

The chiggers attacking man are the larvae of mites belonging to the family Trombidiidae and especially to the genera *Trombicula* and *Eutrombicula*. The adults are large mites, sometimes being as much as half an inch long, and vary in color from light to dark red. The nymphs and adults are believed to feed on decaying vegetation in the soil, but the larvae are predaceous upon various kinds of animals, including snakes. The eggs are laid in the soil. The young larvae make their way to the surface and crawl up on grasses, weeds, or other low foliage, where they lie in wait for a victim.

When the chigger has become attached by means of its sharp mouthparts it remains for two to three days. Within a few hours the area surrounding the mite becomes reddened, quickly swells, and later develops into a water blister. Even before the swelling occurs there may be intense itching. Scratching increases the irritation. On man the mites usually attach themselves in places where the clothing fits tightly, such as beneath a belt or garters, but they may be located on any place on the body. When present in large numbers there may be a slight fever but the chief unpleasantness results from the intense irritiation and the resulting lack of sleep.

Chiggers occur throughout the temperate and tropical regions, less abundantly in the north. There is no control, but some protection may be obtained by changing clothes immediately after returning from the field and taking a hot bath with plenty of strong soap lather. Tall weeds and grass harbor large numbers of the mites and these areas should be avoided if possible. Sprinkling flowers of sulphur or pyrethrum on the body under the clothing is said to give some protection. The internal use of sulphur, which is exuded in perspiration, also has been recommended.

The itching caused by the mites may be alleviated by the use of a paste made with bicarbonate of soda or by dabbing the itching spots with rubbing alcohol or ether. "Lather-less" shaving creams are recommended both as a preventive and to lessen the itching.

RAT MITES

Rat mites *(Liponyssus)* are extremely small creatures that act in the same way as chiggers. They are to be found in buildings and are often the cause of considerable discomfort to man. While the swellings produced are much smaller than those caused by chiggers,

they are equally as irritating for several hours. The mites attack both rats and mice and frequently become abundant in their nests. The control of these rodents will eliminate the mites but it may be several weeks after the destruction of the rodents before the mites disappear.

SPIDERS AND SCORPIONS

The universal fear of spiders and scorpions has little basis in fact, for these creatures play a relatively minor role among the arthropod pests of man. Unlike some of the mites which are true parasites, these animals are accidental attackers. Occasionally they injure man directly by injecting venom into his body. Although much still remains to be learned about the exact virulence of some of the incriminated arachnids it is certain that the great majority of spiders and many scorpions are harmless. Their venom has been specialized to kill insects and other invertebrates for food and is, with several notable exceptions, relatively impotent when introduced into the bodies of warm-blooded animals. As far as is known, these arachnids do not transmit diseases of man.

THE VENOMOUS SPIDERS

The average spider bite produces a painful sensation comparable to that of some of the biting flies, and there follow slight local reactions at the site of the punctures. Only a few species from among many thousands secrete a venom which, differing qualitatively, is capable of producing serious neurotoxic symptoms and rarely even causes death.

Most of the largest and seemingly most formidable of all spiders, the tarantulas or bird-spiders, are considered to be relatively innocuous. A few of the American species have been singled out as being possible exceptions but as yet too little is known about their actual virulence. Species of a related family found in Australia, *Atrax robustus* and *formidabilis* of the Diplurida, seemingly possess a venom that is highly neurotoxic and is capable of causing systematic distress comparable to that of the notorious "black widow" spider.

A considerable number of true spiders have been accused of being venomous through prejudice or circumstantial evidence, but few have been demonstrated by modern investigators to be truly dangerous. The famed European tarantula *(Lycosa tarentula)* is now known to be a relatively harmless creature.

The most notorious of all the venomous spiders are the species of *Latrodectus*. Found in temperate and tropical regions throughout most of the world, the various species have been justly regarded by many different peoples as being especially dangerous. The "Malmignatte" of southern Europe, the "Katipo" of New Zealand and the "Black Widow" of the United States are shining black spiders, strongly marked with red. Other species, such as the "Knobbie Spiders" of South Africa, are less brightly colored, but the venter is always marked by an X-shaped paler maculation, the "hourglass."

Probably the best known species of the genus is the black widow *(Latrodectus mactans)*, found throughout a

large part of North and South America. This spider spends most of its life in a coarse, irregular web located in burrows, crevices, or recesses under rocks or trash. The disturbed and littered areas around man's homes and outbuildings are favorable situations, and not infrequently these spiders are found in the buildings themselves. Bites occur when man accidentally brushes against or squeezes a spider and the creature instinctively bites and injects venom until it is free to run away. Following the injection of venom, come sharp to excruciating muscular pains accompanied by nausea, profuse perspiration, difficulty in breathing, and other symptoms. In the average case the severe symptoms abate within a few hours and normality is attained within a few days. Relatively few people die, as is indicated by Dr. E. Bogen, a foremost authority on the medical status of the bite, who stated that "I am unable to find more than twenty deaths in the past four hundred years due to the Black Widow."

Treatment of black widow bite consists for the most part of measures to relieve the pain (sedatives, hot baths, intravenous injection of epsom salts) during the severe stage. Do not use alcoholic drinks or stimulants. A specific anti-venom has been used successfully.

Ordinary insecticides are not recommended for the eradication of venomous spiders. Within limited areas of infestation, such as around and in outbuildings and homes, a systematic search for the spiders and their destruction individually is preferable to general fumigation.

THE VENOMOUS SCORPIONS

The poison gland of the scorpion is located in the specialized last segment of the post-abdomen, and the venom passes through a curved spine or sting. Most species are able to break the skin of man and cause a more or less painful injury, but in general the effect may be described as negligible. However, as in the case of spiders, a very few scorpions have a venom which differs in quality from that of most of their kin, one which sometimes causes severe symptoms or death. Also, as in spiders, the dangerous scorpions are of relatively small size.

A number of virulent scorpions occur in northern Africa, of which *Prionurus australis* and *Buthus occitanus* are perhaps the most important. An effective scorpion anti-venom has been developed. In the Americas there are several species which have come to be regarded as dangerous. The best-known species is the Durango scorpion of Mexico *(Centruroides suffusus)*, which is reputed to cause more deaths each year than the black widow spider. Most of the deaths occur in children under ten years of age. The symptoms include numbness following the sting, then itching of the nose and throat, excessive production of saliva, a gradual collapse and waves of convulsions, following which comes gradual recovery or possibly death. Treatment for the sting includes sedatives, hot baths, and the use of a serum. A similar species of scorpion *(Centruroides sculpturatus)* occurs in Arizona and is reported to have caused twenty-five deaths from 1929 to 1938, chiefly in children.



Universe through a Microscope

THE PROTOZOA

by ROY WALDO MINER

HE AMERICAN MUSEUM OF NATURAL HISTORY

Universe Through a Microscope

THE PROTOZOA

By

ROY WALDO MINER

GUIDE LEAFLET SERIES

of

THE AMERICAN MUSEUM OF NATURAL HISTORY

No. 114

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▼ A MINUTE SEA-CREATURE *(Trypanosphæra regina)*: one of the Radiolaria. These tiny animals construct a skeleton of natural glass from the silicon dissolved in sea water. The nucleus, which directs the life-activities of the creature, is contained within the latticed sphere in the center. The photograph is of a glass model representing the animal highly magnified, constructed by Herman Mueller, the Museum's skillful glass-modeler



Universe Through a Microscope

The *Protozoa*

By [illegible] MINER

Tiny creatures that swarm by the million in water everywhere. A world invisible to the naked eye but of great importance to mankind

PHOTOGRAPHS BY CHARLES H. COLES, *American Museum*

IN this world of struggle between millions of human beings, it is hard to realize that, invisible to our eyes, another world composed of billions of organisms is pulsing with complicated life activities in our very midst and carrying on a struggle that has continued through eons of time since long before man, or, in fact, all other animal life, came into existence. The invention of the microscope, three centuries and a half ago, created a window through which the great naturalists of that time were able to peer into this universe of minute creatures hitherto totally unsuspected by mankind.

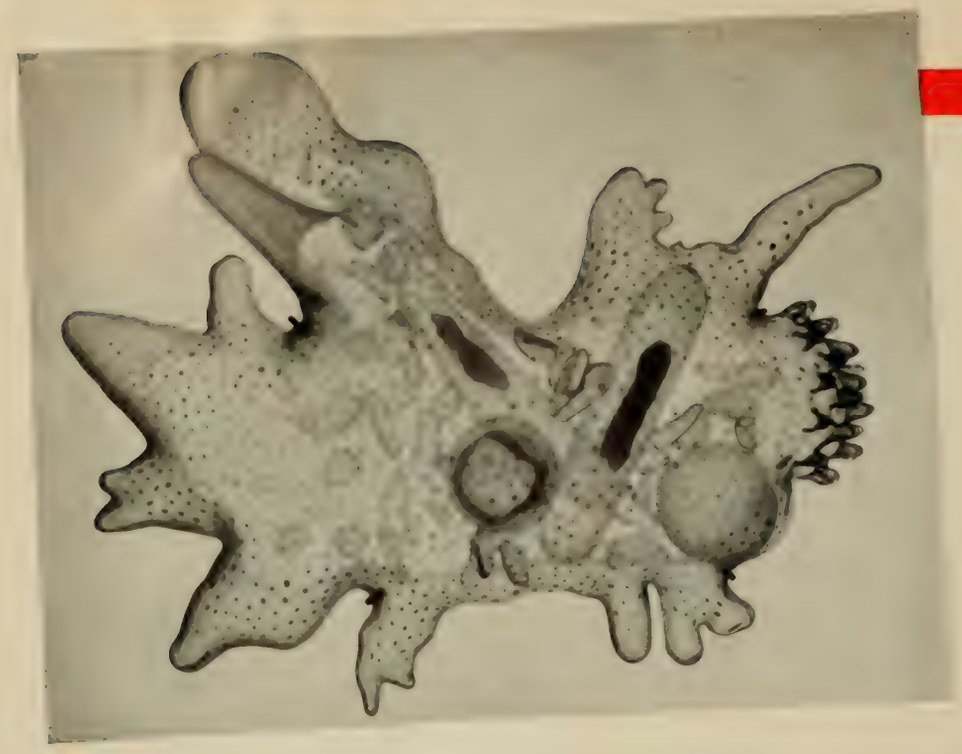
Conspicuous in this microscopic life are the teeming Protozoa. With their minute bodies consisting of but a single cell, they were among Nature's first experiments in animal life. Yet the ancient trial was a success, for they still live and penetrate all the zones of existence. They inhabit the earth from the equator to the arctic regions, from the highest mountain tops to the deepest abysses of the ocean. Wherever there is moisture they exist, and, in their resting stages, they bide their time in desert places. They swarm over aquatic vegetation and multiply in pond and stream. They float in the open ocean by myriads





▲ LOOKING THROUGH the microscope into an otherwise invisible world, Doctor Miner selects the tiny creatures from which greatly enlarged models are to be constructed in glass for the American Museum's exhibit of Protozoa. Each animal must be carefully studied and drawn before this is possible. Skilled artists are used for this purpose

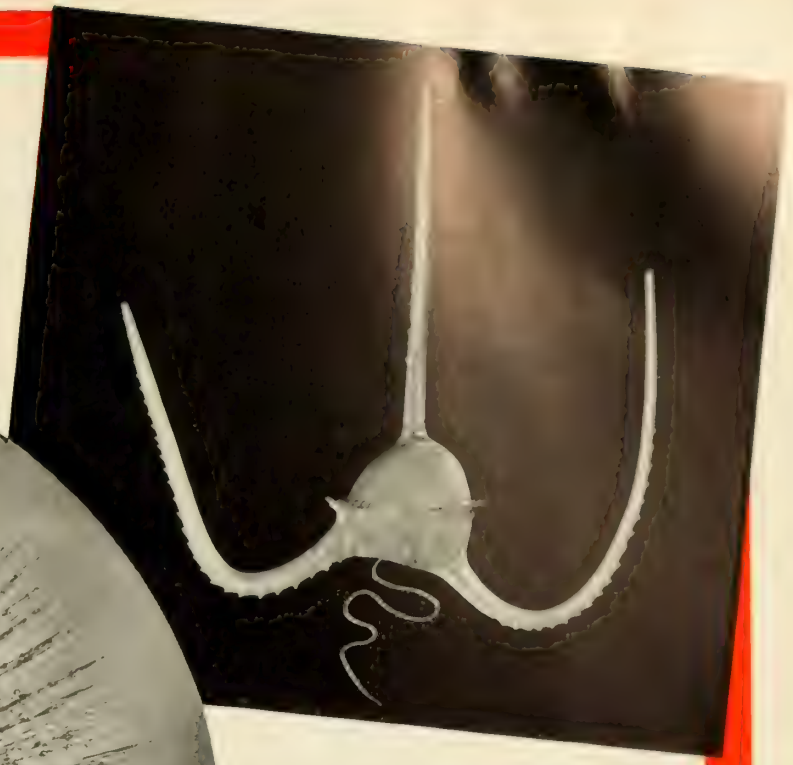
◀ HERMAN MUELLER, the Museum's wizard in glass, exercises his remarkable skill in modeling countless delicate structures over a hot flame to produce his wonderful protozoan models



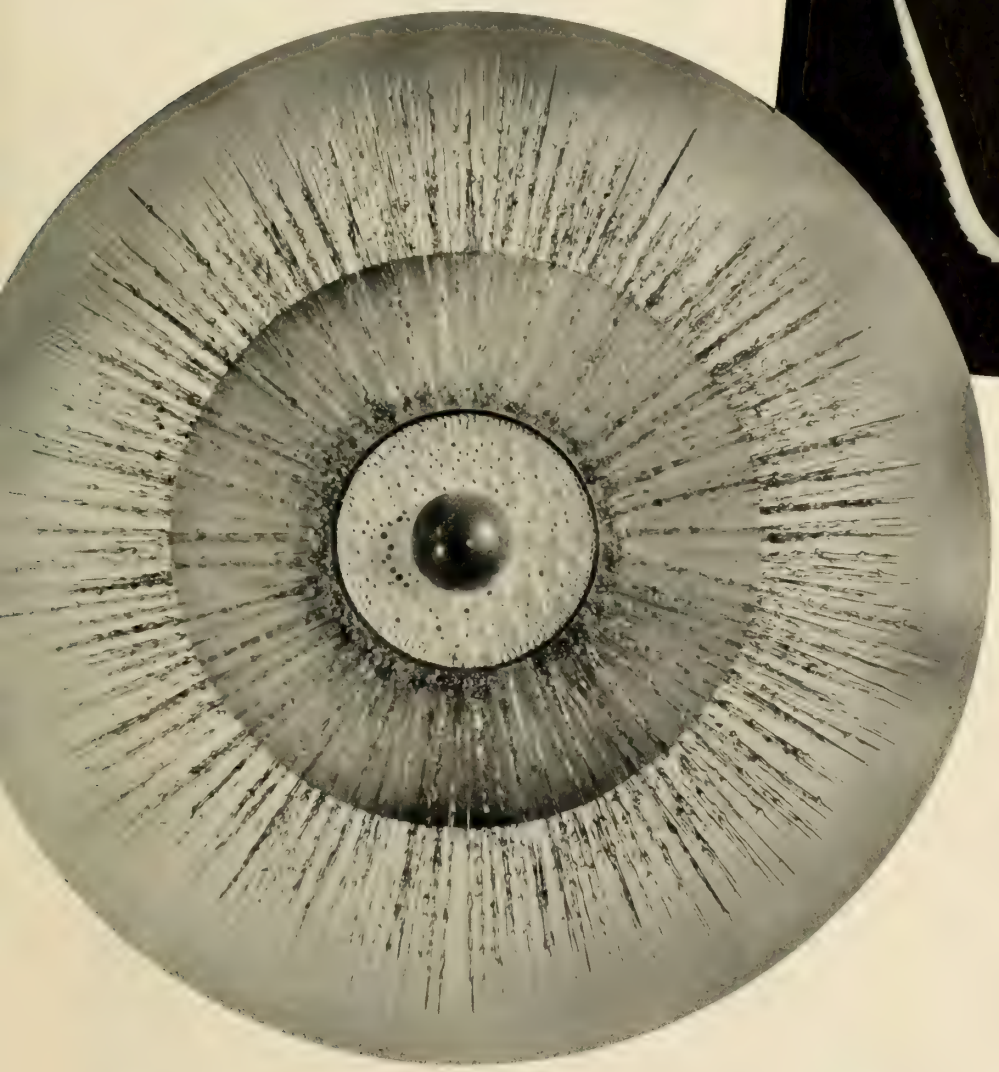
◀ ONE OF THE SIMPLEST of all living animals, the microscopic single-celled *Amoeba* resembles an irregular mass of living jelly, moving about by extending finger-like projections of its substance and flowing into them. The round nucleus is visible near the center of the body. A bubble-like "contractile vacuole" at the right is about to expel detritus into the surrounding water. This model, like the others, is of glass and represents the animal highly magnified. The *Amoeba* is common in fresh water

▼ UNLIKE the related naked *Amoeba,* the *Globigerina* builds a many-chambered shell of limestone. These creatures are so numerous, floating in the open sea, that, when they die, their shells gradually accumulate on the sea bottom, forming beds miles in extent. These often solidify into rock. Geologic changes may elevate them above the surface to form limestone cliffs like those of Dover, England. Thousands of related species are known, which build shells in great variety of pattern. Many are fossilized, and among them are certain species found only in oil-bearing rocks, so they are of importance to oil geologists as aids in locating oil deposits. Note the great number of delicate needle-like bodies that had to be set carefully in position on this model





➤ THE PROTOZOAN *Ceratium,* with its peculiarly shaped glassy shell, is particularly abundant in tropic seas, where, at night, the luminescent bodies of these tiny creatures cause the sea to glow in the foaming wake of moving vessels, or when the water is disturbed by oars



▲ THIS BEAUTIFUL CREATURE is among the simplest of the Radiolaria. Whereas most species of the group are equipped with glassy shells, the *Actissa princeps* is shell-less. The spherical nucleus is centrally located within the membrane of the central capsule, while threadlike pseudopodia ("false feet") extend in all directions to secure food

and their fossil shells form the substance of continental rocks. Finally, they penetrate the tissues of all other animal life and gain their livelihood in the intestines and blood stream of the highest animals, including man. While carrying on this part of their career some feast upon man's very tissues and organs, causing many of the most serious of his diseases and culminating in epidemics more fatal than war. Who knows but that Nature's first life experiment may well be her last and that the legions of primitive one-celled creatures that achieved the earliest steps in evolution may finally triumph over the boastful race that fondly imagines it has achieved the summit of evolution, namely, Man himself?

The Protozoa are spoken of as *single-celled animals*. That is, their entire bodies are equivalent in size and living substance to one of the millions of microscopic cells that make up the tissues constituting the organs of our bodies. But there the resemblance ends. For each protozoon is a complete and independent animal, performing within its minute single cell all of the functions that require our entire cellular complex to accomplish.

Within the protoplasm enclosed by its cell boundaries, the protozoon provides for sensation, locomotion, feeding, digestion, assimilation, growth, breathing, excretion, and reproduction. Our enormous equipment of cells is made up of specialized individuals arranged in tissues, which, in turn, are grouped in organs, each with a special function. A muscle cell can do nothing but contract. A digestive cell can only secrete. A nerve cell can only transmit sensory or motor impulses, and so on, all other functions being lost or reduced.

A cell is thus a living protoplasmic entity. In many-celled animals (Metazoa) it is the living unit of structure, while in single-celled animals (Protozoa) it is the entire living organism. The protoplasmic substance of the cell consists of two main portions, the nucleus and the cytoplasm. The former is a rounded, ovoid, or sometimes variously shaped body of greater density than the cytoplasm. It controls the activities of the cell, including the reproductive function. The cytoplasm is the clearer substance composing the rest of the cell, containing various bubble-like vacuoles having to do with digestion and excretion, as well as other inclusions of varied significance to the cell.

The Protozoa are divided into four main groups, which, however, blend at their boundaries through intergrading types, thus showing their fundamental relationship. These are the Rhizopoda, Mastigophora, Sporozoa, and Ciliata.

The Rhizopoda have bodies without regular shape from which they extend club-shaped or threadlike portions of their substance and flow into them in order to move from place to place. They also utilize these projections to secure their prey, which they engulf at any part of their body surface. They may be naked or equipped



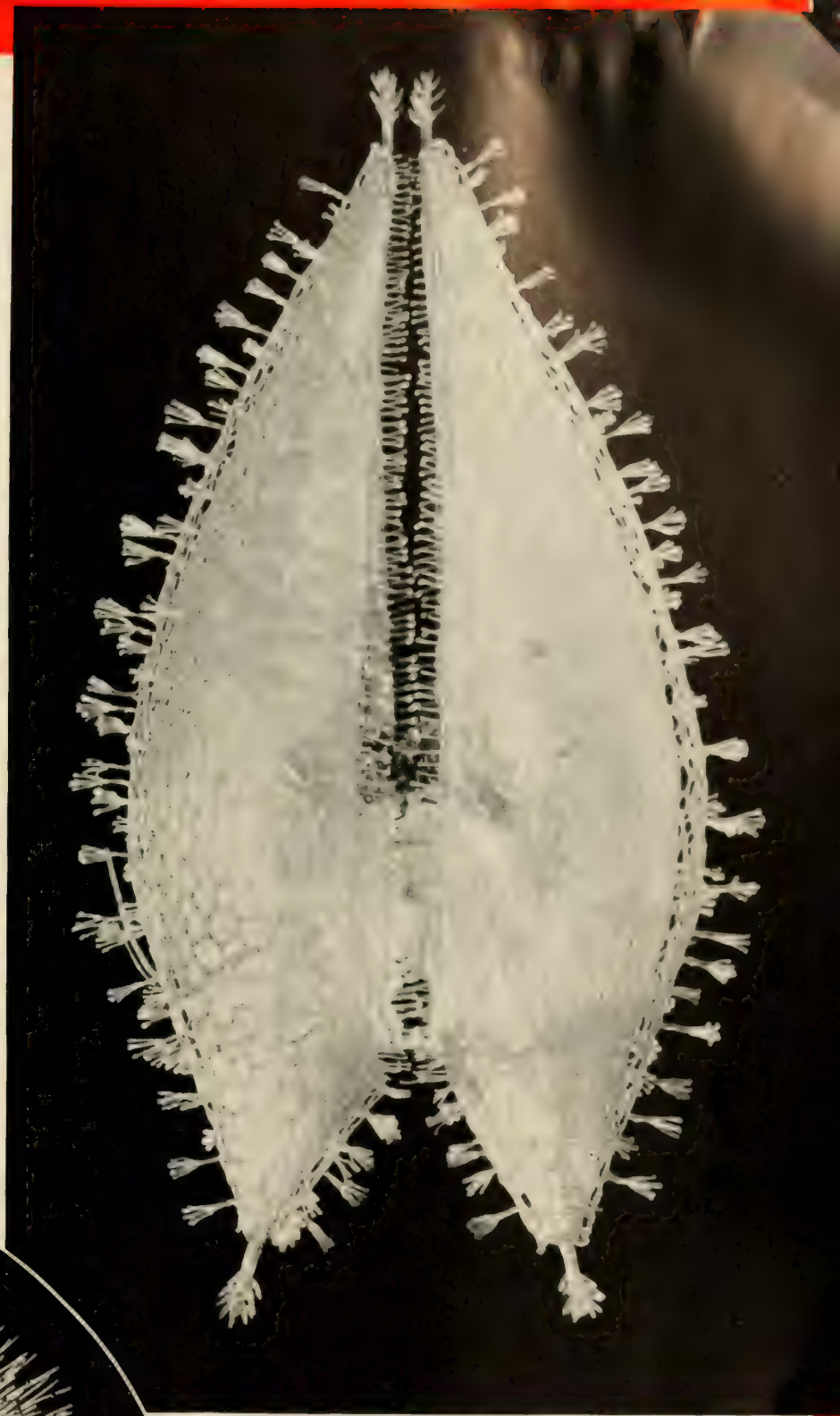
RADIOLARIA produce an almost infinite variety of shell forms. *Dorcadospyris dinoceras,* at left, though a gem of microscopic beauty,possesses a pair of menacingly spiked horns, as its scientific name indicates, that would be terrible if borne by some gigantic prehistoric monster. Actually, the creature is only about the size of a sand-grain

▲ MANY OF THE RADIOLARIA achieve patterns of extraordinary beauty in their crystal shell formations. *Acanthodesmia corona,* though almost literally a "crown of thorns," as its name indicates when translated, has shaped its glassy spikes into a graceful diadem. The models shown here are all on display at The American Museum



▲ THIS is one of the most remarkable of the Radiolaria. *Lithocircus magnificus* has formed a vertical crystal hoop, with branching treelike antlers extending in all directions. The rose-colored central capsule housing the nucleus is seated in this frame, showing a curious cone-shaped structure through its transparent wall





▲ THIS SPECIES *(Coelographis regina)* might well be called the "Queen Radiolarian." It is one of the most highly specialized forms of the group. Between its graceful mitre-like shells is enclosed a complicated central capsule with branching tubelike structures, while the outer surface is a delicately wrought mosaic of lace-work. Incidentally, this is a triumph of glass-modeling technique, being one of the most difficult of Herman Mueller's achievements

◀ THE SERPENTINE RADIOLARIAN *(Collozoum serpentinum)* is a colonial species, made up of many individuals, each with a scarlet, serpent-like nucleus. They surround a central bubble-like mass from which the protoplasmic filaments of the colonial pseudopodia project in all directions

▼ THOUGH not as huge as the Queen Radiolarian, nevertheless the *Aulonia hexagonia* is of good size, being 1/8 of an inch in diameter. It is enclosed in an almost perfect sphere of glass lacework made up of multitudes of hexagonal meshes. It is found floating in abundance at the surface in the tropical Atlantic



with shells of tectin, carbonate of lime, or silicon. Some of these are simple, while others have successive chambers arranged spirally or otherwise. Many show delicate and complex patterns.

The Mastigophora ("whip-bearers") are distinguished by a usually more definite body form, and by one or more flagella, or flexible whips, with which they lash the water and thus move rapidly from place to place. Some form colonies, while others are parasites, causing diseases dangerous to higher animals and man.

The Sporozoa are internal parasites on larger animals. They are of simple form and reproduce by means of multitudes of spores. Hence the name. Some of these also are the source of serious human diseases.

The Ciliata are so called because their bodies are covered with numerous closely set cilia, or hairlike projections, much smaller than flagella, but, like them, used for propulsion. They have a more complicated nuclear apparatus and much more specialized structure than the other groups. They are mostly free-swimming organisms and, in certain species, reach a higher degree of unicellular specialization than any other Protozoa.

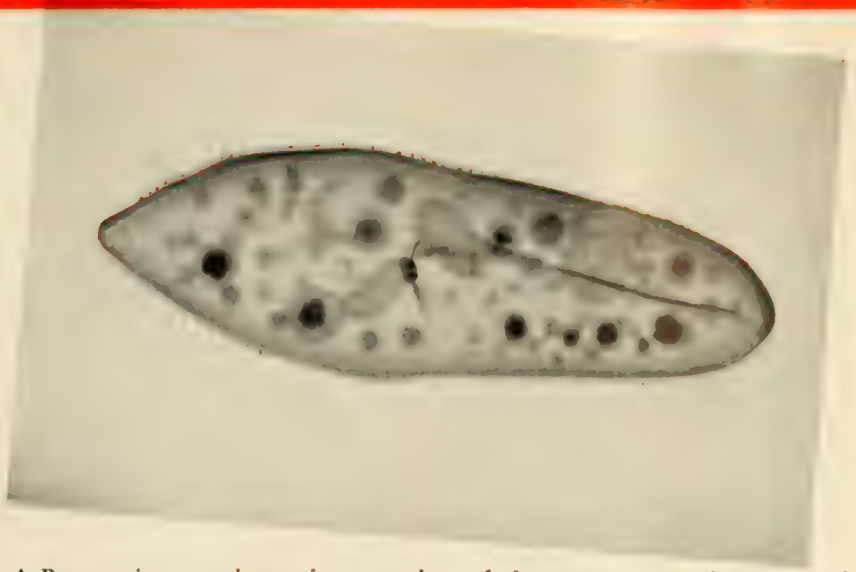
Each of these four groups has followed its own particular road of evolution, starting with comparatively simple types that show evidences of relationship to the other groups and then evolving more specialized forms peculiar to each group.

Among the displays in the Darwin Hall of the American Museum of Natural History, there is an alcove devoted to the Protozoa, in which may be seen a series of glass models accurately portraying these organisms on a highly magnified scale, beautifully wrought by the Museum's skillful glass modeler, Herman Mueller, many of them under the writer's direction. Outstanding examples of his work are depicted in this article.

Here, some of the most typical Rhizopoda are shown, beginning with the primitive *Amoeba* with its naked irregularly shaped body, through the transparent walls of which may be seen the oval nucleus, the bubble-like contractile vacuoles, the food vacuoles, and other internal features. The Foraminifera have bodies like *Amoeba,*

but equipped with protective shells of limestone, the most conspicuous of which (*Globigerina bulloides*) is represented by a beautiful model. This organism floats by the million in the open ocean and, when it dies, its tiny spiral and spiny chambered shell sinks slowly with thousands like it to the sea-bottom, where they accumulate as Globigerina ooze in banks hundreds of feet in thickness and many miles in extent. During past ages, many of these banks have hardened into rock and, in some cases, through geologic changes, have been raised above sea-level to form continental limestone cliffs. The chalk cliffs of Dover, England, were formed in this way.

Other microscopic marine creatures of tropic seas are the Radiolaria. These manufacture their lattice-like "skeletons" from natural glass, i.e., silicon, with a chemical formula closely akin to that of opal. They are wrought into patterns of unbelievable delicacy and beauty. A fine series of glass models in the alcove exemplifies the intricate variety of these. Like their lime-producing relatives, the glassy skeletons of the Radiolaria are extensively deposited in beds of siliceous ooze on the ocean floor, forming a fine, flinty sand, which, under the name of Barbados earth, is used by jewelers as an abrasive for polishing and grinding precious stones.



▲ *Paramecium caudatum* is a member of the numerous and specialized ciliate protozoans. Its body is shaped for rapid motion, being propelled by multitudes of tiny hairlike cilia, which cover its surface

▼ THE GOBLET-CELL *(Monosiga gracilis)*: one of the Whip-bearing Protozoa, or Mastigophora. Its long, slender whip is here surrounded by a thin goblet-shaped membrane. The threadlike stalk anchors the creature to the pond bottom



The radiolarian animal, like the other rhizopods, extends pseudopodia from all parts of its body, radiating like delicate filaments to form a trap in which other organisms are caught. These are entangled by the filaments, which surround them with protoplasm and draw them toward the central organism, digesting them as they do so. The radiolarians are also complicated in having an oval central capsule within which the nucleus is contained. Foamlike bubbles between the protoplasmic threads have a hydrostatic function, enabling the animal to expand along the radiating bars of its glassy skeleton, thus reducing its specific gravity, so that it rises toward the water-surface, and sinks again upon contracting.

Some of the Radiolaria enter into an extraordinary partnership with tiny globe-shaped organisms belonging to the group Mastigophora, scattered throughout its foamy body. These are yellow in color, due to chlorophyll, which enables them to form their food in the presence of sunlight from carbon dioxide excreted by their animal-feeding partner. In this process, they

release oxygen which, in turn, is needed by the radiolarian.

The Ciliata are found both in fresh and salt water. Unlike the Rhizopoda, they have a definite body form and the outside is covered with close-set ranks of cilia or small hairlike structures, vibrating in unison, like tiny oars, to drive the creature through the water. In the various species, there is a great variety of shape as shown by the ciliate models in the alcove. One species (*Paramecium caudatum*), familiar to students, is streamlined like a submarine boat and has an equipment of multitudinous moving hairs arranged spirally, so that the animal rotates as it swims. Larger cilia, fused together in groups, line a shallow but gradually deepening trough (cytostome), the cell's equivalent for a mouth, and create a current in the water, which drives smaller protozoans, diatomes, and food-particles generally down through a tubelike "gullet," at the internal end of which a bubble forms to receive it. This "food vacuole," by means of fluid ferments, digests the prey while moving along the streaming currents of the internal protoplasm. Ciliata also have two nuclei, a larger and a smaller one. In many cases, highly specialized structures within the cell (organelles) perform special functions foreshadowing the many-celled organs of higher animals. In fact, some species of this group are considered to be the most highly organized of the Protozoa.

The Mastigophora start off with species of simple organization having changeable amoeboid bodies like those of the Rhizopoda, but, nevertheless, furnished with a whiplike flagellum for propulsion. Most species, however, possess a definite body form without cilia like those of the Ciliata, but with one, two, or several long flagella which propel them through the water.

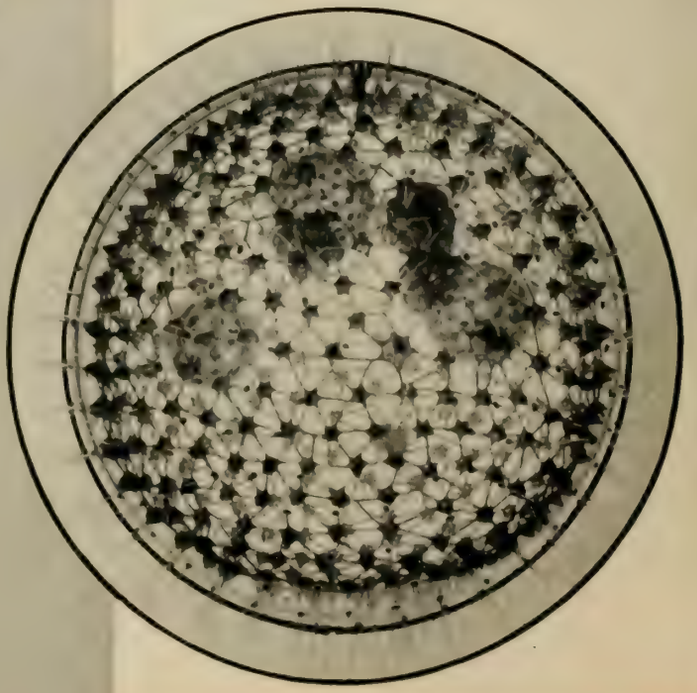
Some have a cytostome ("mouth") at the base of the flagellum, through which small organisms are taken into the interior. Others have no mouth, but, within the body, there are green, brown, or yellow structures equipped with chlorophyll, thus enabling them to obtain their food, like plants, in the presence of sunlight. This difference in feeding, which, in higher plants and animals, is so clear a distinction between the two great kingdoms, is here a matter of variation in related groups. So that, in this group of one-celled organisms, one may look for the first divergence between the Animal and Plant Kingdoms.

Some of the Mastigophora (Choanoflagellata), possess a delicate, transparent, collar-like structure around the base of the flagellum, which aids in food capture. Such species are often anchored to some object by means of a slender stem and so are stationary. In others, these stems are united to each other so that the individuals form a



◂ THE PROGENITOR INDIVIDUAL of this colonial "family tree" *(Stylobryon petiolatum)* has died, leaving its goblet-shaped house behind. Its four children have anchored their homes on the rim of the parental edifice and may be seen as tiny "collared animalcules" through the transparent walls of their dwellings. To the rims of these, in turn, are attached their offspring of the second generation, which have budded from their own parents, in the manner seen in the "house" of one of their own companions. A fourth generation has been added, and a fifth has started. The animal at upper left has suddenly divided into multitudes of spores

▾ *Volvox globator*: a remarkable colony of 1200 or more members, described in the text



group or colony, which may be either fanlike or united in a spherical cluster of many similar individuals. In the case of the species *Volvox*, there are a thousand or more individuals united to each other by a network of protoplasmic strands around a hollow sphere, each member of the colony possessing two flagella, by the combined motion of which, the colony rotates through the water.

It would be hard to say, at first glance, whether *Volvox* is a colony of single-celled organisms or a single many-celled organism, were it not that the various individuals are capable of existing independently at certain times, while, in many-celled organisms, the cells are dependent upon each other for their existence, being fundamentally specialized structures. Strange to say, there is a foreshadowing of specialization even in *Volvox*. For certain members of the colony become larger than the rest and sink into the interior of the spherical colony, dividing rapidly as they do so, until they form new miniature colonies like that of the parent. Eventually these break through the parent wall and swim away independently. These organisms, therefore, illustrate a method by which many-celled animals and plants may have been evolved from the Protozoa.

Among the Mastigophora are certain tapering organisms, swimming about by means of an erect "undulating membrane," which inhabit the blood of higher animals and man. These are known as *trypanosomes*. Some of them are apparently harmless, but others devour the blood cells and tissues, causing such diseases as African sleeping sickness. Another flagellate is responsible for the disease known as kala azar. Both of these are fatal to man, while related forms cause great depredations among cattle and other mammals. Protozoans of these groups pass part of their lives in insects and are transmitted to the higher animals by biting or, in some cases, by their excrement.

The group Sporozoa contains greatly simplified protozoans, structurally, reproducing by means of spores. They are usually characterized by complicated life histories. Among them are the dreaded organisms that cause malaria and yellow fever, which take an enormous annual toll of human lives. These last diseases are transmitted only by the bite of certain species of mosquitoes, within whose bodies a part of the sporozoans' life history is passed.

These are but a few instances of the protozoan organisms that must be reckoned with. Though they are so minute as to be invisible to the naked eye, because of that very factor, they are all the more dangerous. Mere size is an unimportant matter where vitality is concerned.



◀ A PROTOZOAN COLONY with individuals joining in a spherical cluster: *Synura uvella*. It is sometimes abundant in fresh water reservoirs in early spring. It secretes an essential oil having a fishy flavor, which, though harmless, alarms people when they taste it in their drinking water at such times



▶ THIS VIRULENT SPECIES *(Trypanosoma gambiense)*, during part of its life is parasitic in the human blood, causing the fatal disease known as African sleeping sickness. It is transmitted from one human being to another through the bite of the tsetse fly, within the body of which it passes part of its life history

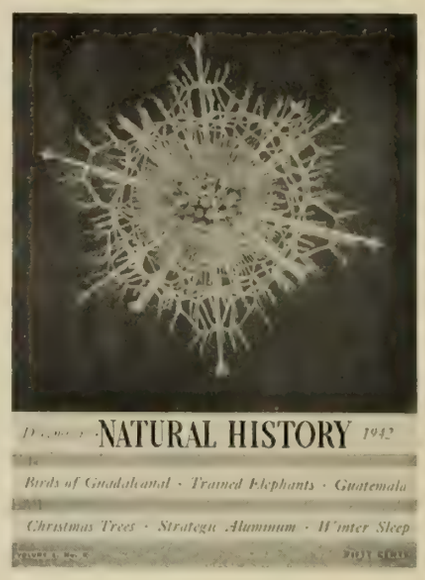


▲ THE deadly sporazoan parasite *(Plasmodium malariae)* which infests human blood to cause malaria. This disease is spread only by the bite of an Anopheles mosquito

THE FRONT COVER

The delicate glass model on the cover of this issue represents the small one-celled animal *Lychnosphaera regina,* greatly enlarged. This tiny protozoan inhabits the surface waters of the Central Pacific. It has a lattice-like glassy skeleton of fragile beauty surrounding the rose-colored clustered lobes of the living animal in the center. Threadlike filaments radiate in all directions to capture still smaller creatures.

The model was created by Herman Mueller, the American Museum's skillful glass blower, under the direction of Dr. Roy Waldo Miner, who, in these pages describes the universe of minute creatures that is revealed by the microscope. Mr. Mueller is shown below assisting Charles H. Coles, the Chief Photographer, in photographing the model in color. The model was rested on a plate glass platform under the carefully adjusted beams of five spotlights. A polarized filter was used to control reflections.



Photographed by Charles H. Coles



Issued under the direction of the
Committee on Popular Publications
Roy W. Miner, *Chairman*

Birds *and* Man

By FRANK M. CHAPMAN



THE AMERICAN MUSEUM OF NATURAL HISTORY

Issued under the direction

of the

COMMITTEE ON POPULAR PUBLICATIONS

Roy W. Miner, *Chairman*



Background painted by Francis Lee Jaques

BIRD LIFE ON THE GREAT BARRIER REEF OF AUSTRALIA. A group in the Whitney Hall of the Museum

BIRDS AND MAN

by

FRANK M. CHAPMAN

A Guide to the Exhibit

Illustrating the Relations between Birds and Man

Shown on the First Floor of the Whitney Wing

GUIDE LEAFLET SERIES, No. 115

THE AMERICAN MUSEUM OF NATURAL HISTORY

NEW YORK CITY

ACKNOWLEDGMENTS

In gathering material for and planning the group on which this leaflet is based the author had the cordial support of his colleagues in the Bird Department. With especial pleasure he also acknowledges the indispensable cooperation of William Patten Osborn as artist and exhibitor. Mr. Osborn was assisted by Mr. Charles Tamkin, E. Thomas Gilliard, Paul Richard and others. The birds were mounted by Raymond B. Potter and George Adams. The vegetation was prepared by George E. Petersen of the Department of Preparation. The lettering was done by Margaret Gilliard and Roger O. Siege. The photographs were made by Thane L. Bierwert.

FRANK M. CHAPMAN

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The American Museum of Natural History
1943

SYNOPSIS OF THE EXHIBIT*

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INTRODUCTORY

There are many parts of the earth occupied by birds where man is unknown; but there is no place inhabited by man where birds are not also found. Their flesh, their feathers, their forms and flight, their habits, their food, their travels, their songs and companionship all may enter into our lives. From the beginning of this association birds have been essentially as they are today but man has risen from the primitive condition, in which some races still remain, to the high stage of civilization his leaders have now reached. We believe that a review of our present and past relations with birds will show that they have played, and continue to play, an inestimably important part in both our mental and physical existence. This review we have attempted to make in the exhibit, "Birds and Man," which this pamphlet has been prepared to accompany.

BIRDS AND MAN

by

FRANK M. CHAPMAN

SECTION I

BIRDS AS FOOD



. CAPE YORK ESKIMO NETTING DOVEKIES. This is drawn by W. P. Osborn from photographs by Donald B. MacMillan.

The Native Hunter. — Most birds are edible; some of them are exceptionally palatable. It has always been their fate to serve as food. Primitive man is sometimes dependent on them for subsistence. It is probable, for example, that the early Tehuelche could not have lived in Patagonia without the support of the Rhea and its eggs; while the Eskimo could not inhabit Cape York, Greenland, if the Dovekie was removed from his larder. In both these instances, it should be noted, agriculture is impossible or not practiced and the indigenes exist mainly, or wholly, on a fare of flesh. But it is significant to observe that in continental areas, at least, the wants of the native rarely, if ever, caused a serious diminution in the numbers of birds. Should this fall below the point of support or profitable pursuit, change in the pursuer's food or habitat automatically gives his prey an opportunity to regain its status.



II. THE CHRISTMAS SEASON—GAME STAND IN FULTON MARKET, NEW YORK. Drawn by A. B. Frost. (A print from Harpers Weekly, 1878.)

The Market Hunter. — With the increase in population following the white man's appearance and improvement in transportation which made trade-centers accessible, the Market Hunter arose and his efforts to supply the demand for edible birds mark one of the most destructive periods of our relation with birds. In North America, Wild Pigeons, exceptionally vulnerable because of their communal habits, in spite of their incredible abundance, were among the first to disappear. Other species, which could be killed by wholesale, were on their way to follow them. Our markets were glutted with game birds as our copies of contemporary prints demonstrate. Obviously we were recklessly squandering an invaluable asset that could never be replaced.

For example:

In 1864, one shipment of Prairie Hens weighed 20 tons. (D. G. Elliot.)

In 1861, 14,850,000 wild Passenger Pigeons were shipped from the Petoskey, Mich., "nesting."

In 1909, 5,719,214 game birds were sold in the markets of New Orleans.

Fortunately, the danger was seen by true sportsmen who, as the first step in reform, secured the passage of laws prohibiting the sale of birds for food. This ended the day of the Market Hunter.

Hunting for Sport. — The Market Hunter was succeeded by the Hunter for Sport. He gratified his inherent love of the chase but created and obeyed the laws shortening the open season, limiting the size of the daily bag, and aiming to restrict the annual kill to not more than the annual increase. He advocated enlargement of suitable habitat with additions to the food supply; in short, spared no effort to augment the parent stock. Of recent years the lives of an increasing number of sportsmen give an encouraging forecast of a change of heart among their kind. As they become older, interest in the living bird replaces the desire to capture it, and the inborn love of the chase finds an outlet in bird photography. It requires more skill to secure a satisfactory picture of a bird than to shoot it, and the trophy obtained is proof of one's patience and ingenuity often of value to science and sometimes to art. Compare the brace of dead Quail bagged by the sportsman with the camera hunter's unique photograph of a colony of nesting Flamingoes and this point becomes clear.

Falconry. — Asia is the home of Falconry. It appears to have been known in China some 2000 B.C. It was practiced in Japan in 600 B.C. and at an equally early period in India, Arabia, Persia and Syria. It was a sport of Ancient Egypt and other parts of northern Africa and was mentioned by Aristotle. It was introduced into England from the Continent about 860 A.D. and was that country's leading sport up to the middle of the 17th Century.

With the increasing use of firearms in hunting, Falconry declined but it is still followed throughout the world, chiefly in Asia. Of recent years a growing interest has been shown in Falconry in America. It is a true sport and the performance of the Falcon and the paraphernalia employed are of greater importance than the quarry pursued.

Falconry has a literature of its own with volumes devoted to its various phases. For a general review of its history and methods read the article in the Encyclopaedia Britannica.

References

1871. Musters, George Chaworth. At Home with the Patagonians. London. Murray.

1914. Hornaday, William T. Wild Life Conservation in Theory and Practice. With a chapter on Private Game Preserves by Frederic C. Walcott. Yale University Press.

1925. Macmillan, Donald B. Four Years in the White North. Boston: The Medici Society of America.

1933. Gross, A. O. History and Progress of Bird Photography in America. Fifty Years Progress of American Ornithology. American Ornithologists' Union.

Section I

BIRDS AS FOOD

(See opposite page)

Patagonia Tehuelches pursuing Rhea with bolas. Partly drawn by W. P. Osborn from a photograph of gauchos by Martin Munkacsi.

A Rhea's egg is also shown.

Cape York, Greenland Eskimo netting Dovekies. Drawn by W. P. Osborn from photographs by Donald B. Macmillan.

Dovekie is also shown.

Display of Dakota game birds by Market Hunters about 1875. A contemporary print.

Game in a New York City market. A print from Harpers Weekly, 1878.

The Quail Hunter. Drawn by W. P. Osborn,
and (below) his bag.

The Camera Hunter and (below) his "bag" of Flamingoes. By F. M. Chapman.

Peregrine Falcon or Duck Hawk Hooded for Hunting.

BIRDS AND MAN

MAN HAS ALWAYS BEEN ASSOCIATED WITH BIRDS. HIS DEVELOPMENT, FROM SAVAGERY TO CIVILIZATION, HAS BEEN ACCOMPANIED BY AN INCREASING REALIZATION OF THEIR POWER TO ADD TO HIS WELL-BEING. AT FIRST KILLED FOR FOOD THEY ARE NOW PROTE[illegible] THIS ALCOVE [illegible] THIS CHANGE IN THEIR [illegible]

SYNOPSIS

SECTION I BIRDS AS FOOD
THE NATIVE HUNTER
THE MARKET HUNTER
HUNTING FOR SPORT

SECTION II BIRDS AS CLOTHING AND IN ADORNMENT
BIRDS AS OMENS AND SYMBOLS; IN MYTHOLOGY AND TRADITION

SECTION III BIRDS AS EMBLEMS AND INSIGNIA
BIRDS AS HIEROGLYPHS

SECTION IV BIRDS IN BOOKS
LITERATURE
HISTORY
SCIENCE

SECTION V BIRDS IN ART

SECTION VI ECONOMIC ORNITHOLOGY I
THE FOOD OF BIRDS

SECTION VII ECONOMIC ORN[illegible]
DOMESTI[illegible]

SECTION VIII ECONOMIC ORNITHOLOGY II
INTRODUCTION OF BIRDS
THE FEATHER TRADE
GUANO
BIRDS AS PETS

SECTION IX THE SENTIMENT OF BIRDS
BIRD SONG
BIRDS AS FRIENDS
BIRD SANCTUARIES

BIRDS AS FOOD

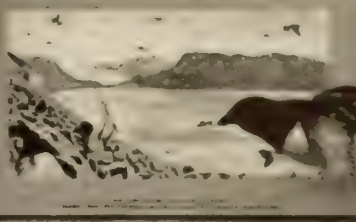
THE NATIVE HUNTER

ON PRAIRIE LANDS BIRDS HAVE ALWAYS MET THE DEMANDS OF NATIVE MAN FOR FOOD. EVEN WHEN HE HAS BEEN DEPENDENT ON THEM FOR HIS EXISTENCE THEY HAVE CONTINUED TO FILL HIS NEEDS.

FOR EXAMPLE, THE ESKIMO COULD NOT LIVE IN THE MORE NORTHERN PARTS OF GREENLAND WITHOUT THE AID OF THE DOVEKIE FOR FOOD, AND THE TEHUELCHE INDIANS COULD NOT HAVE OCCUPIED PATAGONIA WITHOUT FEEDING ON THE FLESH AND EGGS OF THE RHEA.

NOTE THAT IN EACH REGION AGRICULTURE IS IMPOSSIBLE OR UNPRACTICED.





THE MARKET HUNTER

WITH INCREASE IN POPULATION AND CIVILIZATION THE DEMANDS OF MEN FOR BIRDS AS FOOD BECAME LARGER, THE PROFESSIONAL HUNTER AROSE, IMPROVED TRANSPORTATION CREATED NEW MARKETS AND THE DEMAND WAS UNLIMITED. THE RESULT WAS GREAT DECREASE OR EXTINCTION OF THE BIRDS [illegible] KNOWN.

IN 1864 ONE SHIPMENT OF PRAIRIE HENS WEIGHED 20 TONS.
IN 1871, 14,250,000 WILD PASSENGER PIGEONS WERE SHIPPED FROM THE PETOSKEY, MICH., "NESTING".
IN 1909, 2,719,284 GAME BIRDS WERE SOLD IN THE MARKETS OF NEW ORLEANS.

THEREFORE, TO PRESERVE BIRDS FROM EXTERMINATION THEIR SALE AS FOOD HAS BEEN PROHIBITED BY LAW.





HUNTING FOR SPORT

IN THIS COUNTRY MARKET-HUNTING HAS BEEN ELIMINATED, BUT HUNTING FOR SPORT REMAINS. THE MANIFOLD CHARMS OF BIRDS MAY MAKE INCREASING CLAIMS ON THE SPORTSMAN'S AFFECTIONS, BUT LOVE OF HUNTING IS TOO DEEP-ROOTED TO YIELD COMPLETELY TO THE MORE RECENTLY DEVELOPED SENSE OF KINSHIP AND SYMPATHY WITH THEM.

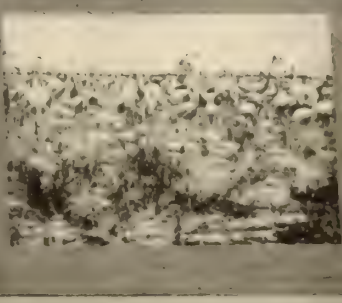
IN SOME INSTANCES THE CAMERA MAY REPLACE THE GUN, BUT, AS A CLASS, THE SPORTSMAN [illegible] TO THE INSTINCTS OF HIS ANCESTORS, PLUS THE AD[illegible] OF THE DOG AND MODERN EQUIPMENT, SOMETIMES EVEN [illegible] FALCONS. THERE ARE NOT LESS THAN TEN MILLION [illegible] IN THIS COUNTRY. IN SPITE OF BAD RESTRICTIONS [illegible] THEY KILL TWELVE MILLION WILD-FOWL ANNUALLY. [illegible] MAN CONTINUES TO GRATIFY HIS INHERENT [illegible] BIRDS FOR SPORT, [illegible] THEIR [illegible] THEIR NUMBERS, AND IMPROVE THEIR PROTECTIO[illegible]











SECTION II

BIRDS AS CLOTHING AND IN ADORNMENT

Fur, rather than feathers, has clothed man. The innumerable instances in which the skins of mammals tanned, as in buckskin, or natural, as in a guanaco pelt, are pertinent illustrations. But the down-lined skins of diving-birds, like the Murre and Dovekie, make warm soft garments and are widely employed by the natives of northern latitudes. Note the Eskimo's hooded shirt of Murre's skins in our exhibit.

Woven feather-garments may also be used but in by far the greater number of cases feathers are worn for meaningless display or as insignia rather than as clothing. I except here the wearing by civilized man, or rather woman, of ostrich boas, swans-down cloaks and similar semi-display apparel as more properly to be considered under the Feather Trade rather than with the use of feathers by indigenes. In considering the employment of feathers for adornment it is difficult to draw the line between casual, meaningless display and actual significance. The necklace of South American parrots' feathers shown was probably only an expression of its wearer's sense of beauty; but it may have indicated rank or profession.

Doubtless feathers only gradually acquired a significance that restricted their use to the man. It was not until symbolism gave way to fashion that feathers were widely worn by woman. Here again we leave primeval, for modern conditions, to be treated as an outcome of the Feather Trade, not as a custom of the indigenes.

BIRDS AS OMENS AND SYMBOLS: IN MYTHOLOGY AND IN TRADITION

The remainder of this, and all the next section, belong primarily in the province of ethnology. Nevertheless birds supply so many of the facts on which the superstitions, beliefs and actions of man are founded that the ornithologist may at least be permitted to name the characteristics that, in his opinion, have exerted the widest and most pronounced influence. Possibly first among them, is the voice of birds, particularly of birds possessing loud, striking notes. The *hoot* of an Owl may reach a hundred or more pairs of ears while the bird remains unseen. So deep and lasting has been the significance attached to Owls' notes, and other ominous bird-calls, that belief in their effectiveness enters into our current superstitions. Doubtless the chief reason for

Owls' invisibility is their nocturnal habits. Their weird cries gain in impressiveness from the mystery of the night.

Following the calls of birds in their power over the untrained mind, we place flight with its marvelous mobility; migration, and its accompanying inexplicable appearances and disappearances; plumage and its varied uses; human-like habits that reflect the customs of men; all have played their parts in the life of primitive man. The depth of his belief in the significance of the traits of birds may be measured by the degree of his ignorance. With the mental development that accompanied increasing knowledge, ritual and augury followed superstition and they faded, in time, to the fable, legend and tradition of today.

Aristophanes was inspired by more than a "Comedy" when he wrote (Frere's translation):

> "For every oracular temple and shrine,
> The birds are a substitute equal and fair
> For on us you depend and to us you repair
> For counsel and aid when a marriage is made,
> A purchase, a bargain, a venture in trade.
> Unlucky or lucky, whatever has struck ye,
> An ox or an ass that may happen to pass,
> A voice in the street, or a slave you may meet,
> A name or a word, by chance overheard,
> If you deem it an omen, you call it a Bird,
> And if birds are your omens, it clearly will follow
> That birds are a proper prophetic Apollo."

The 2300 years, more or less, that have passed since the time of Aristophanes have not removed birds from our fables and folk-lore. We may not interpret literally the significance of an Owl's call at our door, but we wish that the bird had chosen some other person's door! The cry of the Cuckoo, or "Rain-Crow," may not actually arouse our faith in an approaching storm but, at least, it may increase the chances of a shower. And when we speak of the stork as the bearer of babies, or a "Little Bird" as our source of information, we are perpetuating pleasant custom. Countless similar instances of inherited tradition might be cited. Doubtless the reader will recall some of his own.

Section III

BIRDS AS EMBLEMS AND INSIGNIA

Entering Section III of our exhibit we find more definite relations between birds and man than those described in the latter part of the preceding section. Feathers have now acquired recognized meanings and specified uses.

SECTION II

BIRDS AS CLOTHING AND ADORNMENT

(See opposite page)

An Eskimo hooded cape of Murre's skins.

A South American necklace of Parrots' feathers.

BIRDS AS OMENS AND SYMBOLS

Barn Owl.

Jove.

European Cuckoo.

Minerva.

Pegasus.

European Kingfisher.

The Stork races the Doctor.

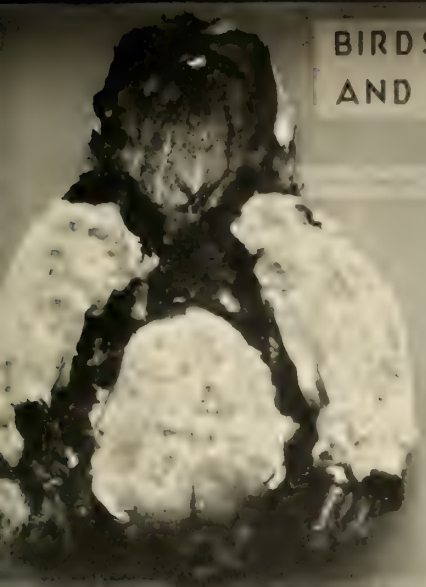
The Winged Sun.

Totem capped by Raven.

Totem capped by Raven.

Raven a bird of ill-omen.

BIRDS AS CLOTHING AND IN ADORNMENT



CLOTHING

ADORNMENT



BIRDS AS OMENS AND SYMBOLS; IN MYTHOLOGY AND TRADITION

TO THE BIRDS' POWER OF FLIGHT, THEIR MYSTERIOUS COMINGS AND GOINGS, THEIR VOICES, VARIED PLUMAGE, AND HUMAN-LIKE CHARACTERISTICS, WE MAY ATTRIBUTE THE INFLUENCE THEY HAVE EXERTED ON THE MIND AND CUSTOMS OF PRIMITIVE AND EVEN MODERN MAN. THIS IS SHOWN IN THE USE OF BIRDS AND FEATHERS AS SYMBOLS AND EMBLEMS IN COUNTLESS MYTHS AND LEGENDS, IN RITES, CEREMONIES AND MOURES, AND EVEN IN CURRENT SUPERSTITIONS, IN FABLE AND FOLK-LORE.





OMENS

AS HUMAN-FACED, NOCTURNAL, WEIRD-VOICED OF MYSTERY, OWLS APPEALED STRONGLY TO IMAGINATION OF EARLY MAN. TO THIS DAY ARE CONSIDERED BIRDS OF ILL OMEN. THE RE PLUMAGE AND RAUCOUS CROAK OF S HAVE CAUSED COUNTLESS SUPERSTITIONS. CUCKOOS' LOUD NOTES ARE VARIOUSLY INTER- IN FABLE AND FOLK-LORE, AND WHERE THE ARE KNOWN AS 'RAIN-CROWS' THEY SERVE THE OF THE LOCAL PROPHETS WHO BASE THEIR NGS, SOMETIMES WITH REASON, ON THE ONS OF BIRDS.





MYTHOLOGY

IN MYTHOLOGY CERTAIN BIRDS WERE ASSOCIATED WITH THE GOD OR GODDESS WHOM IN THEIR APPEARANCE THEY WERE BELIEVED TO TYPIFY. THUS WAS THE POWER OF THE EAGLE THAT MADE IT THE BIRD OF JOVE; THE BEAUTY OF THE PEACOCK THAT CONNECTED IT WITH JUNO; THE ALLEGED WISDOM OF THE OWL THAT MADE IT THE BIRD OF MINERVA

SYMBOLS







WINGS, AS BIRDS' MOST DISTINCTIVE CHARACTER AND AS INDICATIVE OF THEIR MASTERY OF THE AIR, ARE WIDELY USED AS SYMBOLS. THEY ARE GIVEN TO MERCURY AND PEGASUS AS WELL AS TO ANGELS AND EVEN TO THE WIND, AND THE DAY MAY BE BORNE ON THE WINGS OF THE MORNING.

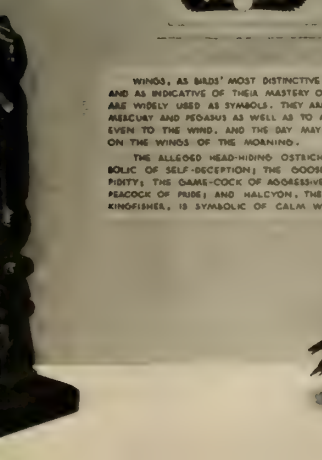
THE ALLEGED HEAD-HIDING OSTRICH IS SYMBOLIC OF SELF-DECEPTION; THE GOOSE OF STUPIDITY; THE GAME-COCK OF AGGRESSIVENESS; THE PEACOCK OF PRIDE; AND HALCYON, THE EUROPEAN KINGFISHER, IS SYMBOLIC OF CALM WEATHER.

CURRENT FOLK-LORE; TRADITION



THE DEPTH OF PRIMITIVE MAN'S BELIEF IN THE SIGNIFICANCE OF THE WAYS OF BIRDS IS MEASURED BY THE DEGREE OF HIS IGNORANCE. WITH INCREASED KNOWLEDGE RITUAL WAS FORGOTTEN, UNFULFILLED OMENS FADED TO SUPERSTITIONS. THESE, IN TURN, BECAME FABLE AND LEGEND AND EVENTUALLY THE INHERITED HABIT OR TRADITION OF TODAY.

THUS WHEN A MAN GRAVELY TIPS HIS HAT TO A MAGPIE, HE FOLLOWS ANCESTRAL CUSTOM. WHEN WE SPEAK OF STORKS AS BEARERS OF BABIES, OR OF 'LITTLE BIRDS' AS BEARERS OF INFORMATION, WE ARE GOVERNED BY TRADITION.





The majestic appearance and predatory habits of Eagles have everywhere made them the emblems of war, and Eagles' plumes are no longer merely feathers, but are worn by the warrior as indicating his "calling" or as evidence of his achievements.

More specifically, feathers give wings to the arrow, messenger of war, and feathers also provide the pen of peace, though it may also be used to promote far from peaceful purposes.

As insignia of profession or rank, feathers are used throughout the world. The Black Cock's quill of the Swiss guide plays a minor rôle but is no less significant than the Peacock's plumes of the Far East potentate. It is singular that in Hawaii, where birds are small and few in species, the most elaborate native feather-work in the world should have been perfected. Only a limited number of the woven feather cloaks worn by Hawaiian nobility are now in existence. They are valued at $10,000 or more.

Incidentally, it is a tribute to the widespread influence of birds that man should have selected characteristic species to be figured on the stamps and coinage of his country. But when the philatelist refers the Dove and the Dovekie to the same bird family he obviously is in need of the services of an ornithologist!

As birds made deeper and more varied impressions on the mind of man they played a more important part in his life. The imitation of birds' calls may have become words in our spoken language, but it is certain that the birds themselves have helped to form a written language. Serving at first as pictographs or ideographs, they later became hieroglyphs and were consistently used as low reliefs on slabs or murals, on papyrus scroll, in codex as interpretable records of contemporary history.

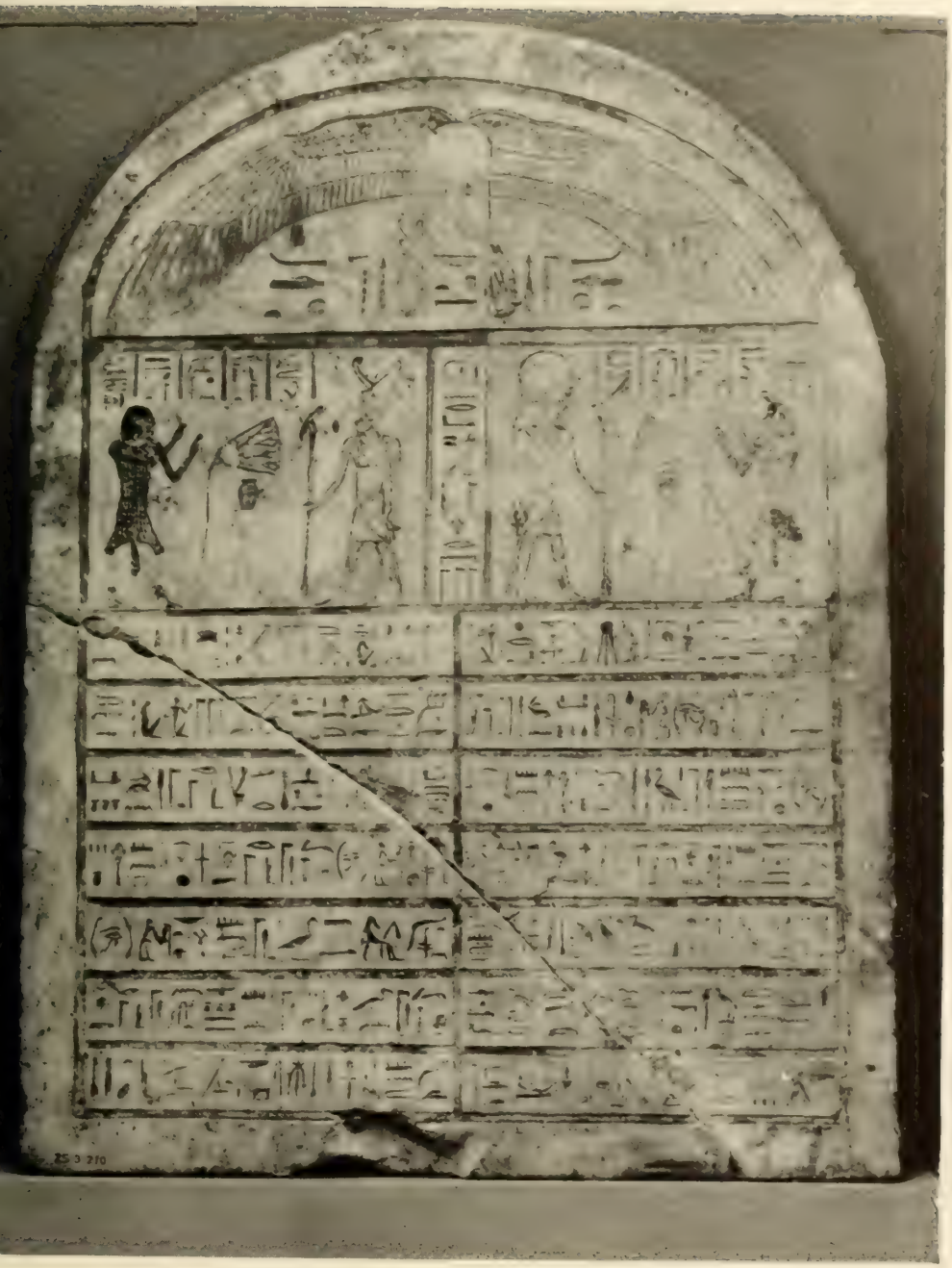
Morcau, who writes with the authority of an ornithologist on the ground, states that 12 named and 4 unnamed species of birds appear in Egyptian hieroglyphs; while Tozzer and Allen, speaking of the three Mayan codices still in existence, write: "These remains of a once extensive literature show evidence not only of considerable intellectual attainments on the part of their authors but also a high degree of artistic skill in the drawings and hieroglyphics" (p. 283). Here is a subject that might be pursued through the beginnings of all languages.

References

1910. Tozzer, A. M., and Allen, G. M. Animal Figures in the Maya Codices. Peabody Mus. Amer. Arch. and Ethn. IV, 3, pp. 283-372.

1923. Ingersoll, Ernest. Birds in Legend Fable and Folklore. Longman, Green & Co.

1930. Morcau, R. E. The Birds of Ancient Egypt. (Meinertzhagen, Richard E., "Nicoll's Birds of Egypt," Chapter III, pp. 58-77).



III. EGYPTIAN FUNERARY STELA. Funerary Stela of Nesi-Khonsu showing bird hieroglyphs painted on limestone. Loaned by Metropolitan Museum of Art from its collections excavated at Deir El Bahri, Thebes, XXVI Dynasty (663-525 B.C.).

Section III

BIRDS AS EMBLEMS AND INSIGNIA

(See opposite page)

Indian War Bonnet of Eagle feathers.

The Dove of peace.

Feathered Arrow.
Quill Pen.

Kiowa Eagle dance.

Hawaiian Chieftain's feather cloak and the bird that supplies the feathers.

Alaskan ceremonial mask.

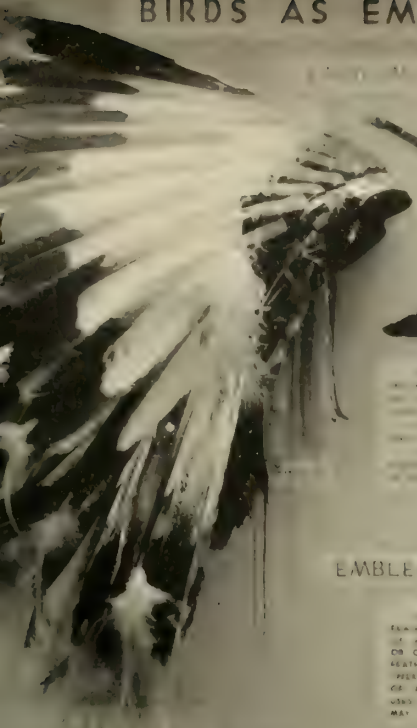
A Medicine Man's plume.

Mayan bird hieroglyphs.

Native birds as Emblems on stamps and coins.

Egyptian bird and other glyphs. Egyptian funerary stela of Nesi-Khonsu showing bird hieroglyphs painted on limestone. Loaned by Metropolitan Museum of Art from its collections excavated at Deir El Bahri, Thebes, XXVI Dynasty (663-525 B.C.)

BIRDS AS EMBLEMS AND INSIGNIA

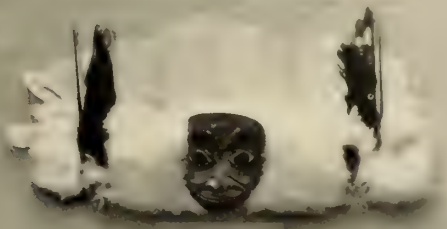




EMBLEMS OF RANK AND



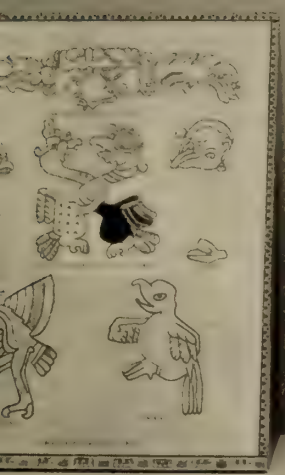


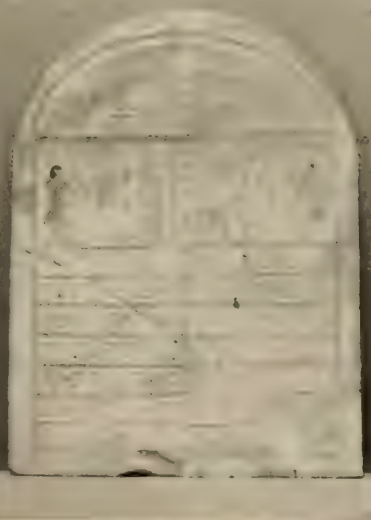




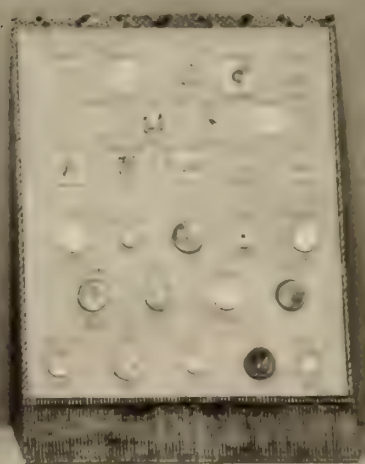


BIRDS AS HIEROGLYPHS





BIRDS ON STAMPS AND COINS



SECTION IV

BIRDS IN BOOKS

Literature. – In considering Birds in Books we accord first place chronologically and historically to the birds of the bible. There is a surprising amount of bird-lore in the bible, chiefly in the Old Testament. About 25 of the larger species are mentioned by name. Smaller ones are referred to under group terms.

Primarily there is a division (Leviticus) into "clean" (= edible) and "unclean" (= inedible) groups in which existing standards are more or less closely followed. The Mosaic law of bird protection, however, contains provisions which to us seem inconsistent. It reads:

"If a bird's nest chance to be before thee in the way in any tree, or on the ground, whether they be young ones, or eggs, and the dam sitting upon the young, or upon the eggs, thou shalt not take the dam with the young:

"But thou shalt in any wise let the dam go, and take the young to thee; that it may be well with thee, and that thou mayest prolong thy days." (Deut. XXII, 6 and 7).

Nesting, migration and song are alluded to usually metaphorically or poetically. Thus Jeremiah (VIII; 7) wrote: "Yea, the stork in the heaven knoweth her appointed times; and the turtle [dove] and the crane and the swallow observe the time of their coming," and Solomon (Song, II, 12) writing, "the time of the singing of birds is come," is a poet and herald of spring.

Thus from the beginnings of literature the sensitive mind of the poet has responded to the influence of birds. It was apparently a popular interest in birds that induced Aristophanes (B.C. 448-385) to use them as the subjects of his comedy, "Birds"; and later, poets "Singing hymns unbidden 'Til the world was wrought to sympathy with hopes and fears it headed not" have most eloquently expressed the emotions birds arouse within us. We have only to recall the works of Chaucer, Shakespeare, Shelley, Wordsworth, Coleridge, Burns and Keats in England, and in America, Bryant, Emerson, Longfellow, Lowell and Whitman to realize how birds have inspired the poets.

Writing some 300 years ago, how well Izaak Walton expressed man's varied debts to birds and, with the prescience of the poet, predicted their future relations. "The very birds of the air," he said, "those that be not hawks, are both so many and so useful and pleasant to mankind that I must not let them pass without some observations. They both feed and refresh him – feed him with their choice bodies and refresh him with their heavenly voices": a point of view more appreciative than consistent.



IV. BIRDS PLAYING A PART IN HISTORY. October 7, 1492. Columbus changed his course to follow land birds, thus shortening his route by 200 miles.

The prose of bird literature is devoted largely to descriptions of bird-life and to experiences with birds in nature. Much of it is to be classed with the science or biography of ornithology. But in America we have as contributors to the prose literature of birds Thoreau, Torrey, Burroughs and many others. Certainly none among them has responded more deeply to the bird in its haunts than Burroughs writing in Wake Robin: "Mounting toward the upland again, I pause reverently as the hush and stillness of twilight come upon the woods. It is the sweetest, ripest hour of day, and as the Hermit's evening hymn goes up from the deep solitude below me, I experience that serene exaltation of

sentiment of which music, literature, and religion are but the faint types and symbols".

History. — It is interesting that the birds of history should so often be recorded as saving man from disaster — starvation, conquest, and the perils of the sea. It was migratory Quail that came to the rescue of the Children of Israel, cackling Geese that saved Rome; southbound migrants that guided Columbus when his discouraged crew was on the verge of mutiny. The event doubtless influenced the history of our continent and is of sufficient interest and importance to be briefly recorded here. On October 7, 1492, Columbus was 720 miles northeast of the Bahamas, when numerous small land-birds, flying southwest, crossed his route. They were the most promising evidences of land that he had encountered, and he altered his course to follow them, thereby shortening his voyage 200 miles and landing in San Salvador, Bahamas, instead of Florida.

Science. — Birds are such many-sided exponents of their environment; they are so abundant and so easily observed that they have induced man not alone to establish a literature and a history of ornithology but to create also a science of birds for the reception of what he learns concerning their structure, relationships, and habits.

Aristotle (B.C. 385-322) is the first ornithologist of record. But birds occupied too important a place in the art and life of the Egyptians not to have also figured in their literature. Indeed, we need go no further back than Aristophanes to find apparent common knowledge of at least our everyday birds. Whether or not Aristotle had predecessors, for the following nearly 2000 years he had no comparable successors. So far was he in advance of his time that, as Warde Fowler remarks, naturalists were content to follow him alike when he was right and when he was wrong. The bibliographer is referred to Alfred Newton's scholarly review of the history of bird literature (Dictionary of Birds, 1896). I mention, therefore, the names of only such outstanding contributors to ornithology during this period as Willoughby and Ray (1676), Edwards (1743), Buffon (1749), Linnaeus (1758) and Brisson (1760).

Provided now with a classification and nomenclature, we may leave the avifauna of the Old World to pass to that of the New.

At about this time Mark Catesby (1731-1743) was producing in London his two great folios on the *Natural History of Carolina*, a work which, after 200 years, is still a notable publication. It was followed by Pennant's *Arctic Zoology* (1784-1787), but the earliest attempt to treat of all the birds of the North America of that day was that of Alexander Wilson (1808-1814), the Scotch poet and weaver, since well-called the Father of American Ornithology.

Wilson's pioneer work laid the foundation for Audubon's incomparable *Birds of America* (1827-1839). Combining in one man the artist, explorer, field student, writer and publisher, Audubon's achievements will always command the world's unstinted admiration. His influence on the growth of bird study was profound. Works on American birds by Baird, Cassin, Coues, Ridgway and others now brought the possibilities of bird study within the reach of everyone. All parts of our country had their bird students and in 1883 they founded the American Ornithologists' Union, which, since its organization, has published *The Auk*, an authoritative quarterly (address, American Museum of Natural History).

From the A.O.U. grew the first Audubon Society (1886) and the Bureau of Economic Mammalogy and Ornithology (now included in the Fish and Wildlife Service). And in these two educational and research institutions we have the roots of the popular and technical phases of the bird study and conservation. The visitor is referred to other parts of this hall for exhibits illustrating the ornithology of today.

At the bottom of this section copies of three different standard works on ornithology are shown: Roberts' *Birds of Minnesota*, Coues' *Key to North American Birds*, and Murphy's *Oceanic Birds of South America*.

SOME BOOKS ON EASTERN NORTH AMERICAN BIRDS

With any of these works the student has made a beginning. But let him visit the Museum's library (5th floor) before making a choice.

*1808-1814. Wilson, A. American Ornithology. Many Editions.
*1831-1839. Audubon, J. J. The Birds of America. Plates, 4 vols. text.
1872. Coues, E. Key to N. A. Birds. Later editions; Last, 1903.
1886. Am. Orn. Union Check List of N. A. Birds. Rev. Editions, 1910, 1931.
1874-1895. Bendire, C. E. Life Histories N. A. Birds. 2 vols.
*1895-1932. Chapman, F. M. Handbook of Birds of Eastern North America.
1901-1942. Ridgway, R., Friedmann, H. Birds of North and Middle America. 9 parts.
*1910. Eaton, E. H. Birds of New York. 2 vols.
1918-1942. Cory, C. B., Hellmayr, C. E., Conover, B., Catalogue of Birds of the Americas. 11 parts.
1919-19—. Bent, A. C. Life Histories N. A. Birds. 14 parts.
*1925-1929. Forbush, E. H. Birds of Mass. and other N. E. States. 3 vols.
*1932. Howell, A. H. Birds of Florida.
*1932. Roberts, T. S. Birds of Minnesota. 2 vols.
*1934. Taverner, P. A. Birds of Canada.
*1937. Stone, W. Bird Studies at Old Cape May. 2 vols.
*1939. Peterson, R. T. A Field Guide to the Birds.
*1940. Todd, W. E. C. Birds of Western Pennsylvania.
1942. Cruickshank, A. L. Birds Around New York City.
*1942. Pearson, T. G., Brimley, C. S. and H. H. Birds of North Carolina.

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* Colored illustrations.

Skylark. Bobolink.

Section IV

BIRDS IN BOOKS

(See opposite page)

Nightingale. Hermit Thrush.

Columbus' vessel the "Santa Maria."

Aristotle. Linnaeus.

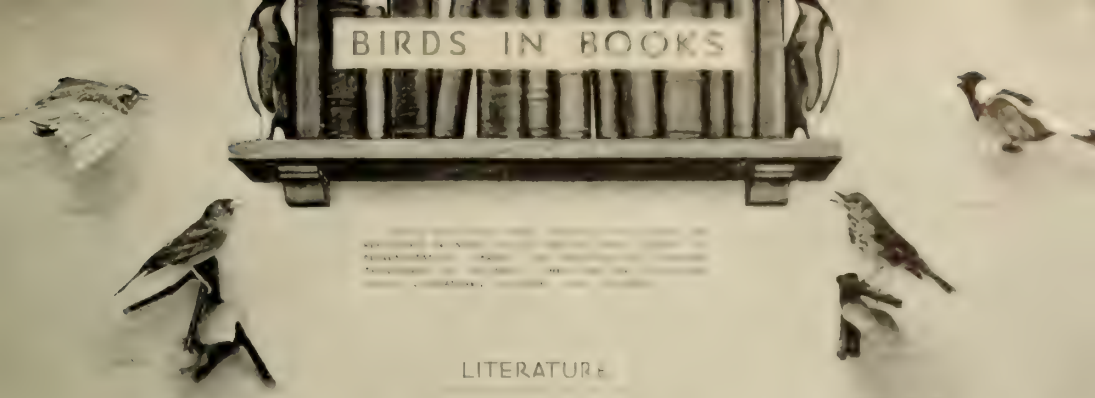
Alexander Wilson. John James Audubon

Annual Meeting of the American Ornithologists' Union, Washington, D. C. Nov. 1892.

Roberts' "The Birds of Minnesota."

Murphy's "Oceanic Birds of South America."

Coues' "Key to North American Birds."



LITERATURE

RST ON OUR LIST OF BOOKS REFERRING TO BIRDS
BIBLE. BIBLICAL REFERENCES TO BIRDS ARE
D CHIEFLY IN THE OLD TESTAMENT. ABOUT 25
R SPECIES ARE MENTIONED BY NAME, SMALLER
BY GROUP TERMS. THE DOMESTIC FOWL IS
RED TO IN THE NEW, BUT NOT IN THE OLD
MENT. ASIDE FROM A DIVISION INTO 'CLEAN'
LE) AND 'UNCLEAN' (INEDIBLE) GROUPS, WHICH
LY FOLLOWS EXISTING STANDARDS, AND THE
IC LAW OF PARTIAL BIRD PROTECTION, BIRDS
USUALLY REFERRED TO IN THE BIBLE METAPHORIC-

ALLY OR POETICALLY. SOLOMON (SONGS, II) WRITING "THE TIME OF THE SINGING OF THE BIRDS IS COME" IS A POET AND HERALD OF SPRING RATHER THAN A RECORDER OF MIGRATION. THUS FROM THE BEGINNINGS OF LITERATURE THE SENSITIVE MIND OF THE POET HAS RESPONDED TO THE INFLUENCE OF BIRDS.

IT WAS APPARENTLY A POPULAR INTEREST IN BIRDS THAT INDUCED ARISTOPHANES (448-385 B.C.) TO USE THEM AS THE SUBJECTS OF A COMEDY, AND ENGLISH POETS OF A LATER PERIOD SEEM TO HAVE BEEN

EVEN MORE DEEPLY MOVED BY THE [illegible] SIGNIFICANCE OF BIRD-LIFE. SCORES THE [illegible] CHAUCER, SHAKESPEARE, COLERIDGE, [illegible] KEATS, SHELLEY, AND BURNS.

THE PROSE OF BIRD LITERATURE RELATES CHIEF TO BIRDS' HABITS AND IS USUALLY CLASSED AS BIRD BIOGRAPHIES OR ORNITHOLOGY. BUT TO M LIKE BURROUGHS, HUDSON AND MANY OTHERS, BIRD IS AN INSPIRATION RATHER THAN A SPECIM AND WHAT THEY WRITE IS LITERATURE RATHER TH SCIENCE.

HISTORY

ORY CONTAINS RECORDS OF INCIDENTS AND EVENTS
H BIRDS HAVE PLAYED A PART IN SHAPING THE
OF HUMAN AFFAIRS. THUS IN 338 B.C. THE SACRED
THAT GAVE THE ALARM WHICH SAVED ROME MAY
RDED A PLACE IN HISTORY; WHILE THE MIGRANT
HAT DIRECTED THE COURSE OF COLUMBUS MAY
NFLUENCED THE DEVELOPMENT OF A CONTI-



ON OCTOBER 7, 1492, COLUMBUS WAS 720
EAST OF FLORIDA AND 303 MILES NORTHEAST O
BAHAMAS. HIS DISCOURAGED MEN WERE ON THE
OF MUTINY WHEN NUMEROUS SMALL LAND-BIRDS,
INO SOUTHWEST, CROSSED HIS ROUTE. HE ALTERE
COURSE TO FOLLOW THEM, THEREBY SHORTENIN
VOYAGE 200 MILES AND LANDED AT SAN SALVA
BAHAMAS, INSTEAD OF FLORIDA.





SCIENCE

RISTOTLE (385-322 B.C.) IS THE FIRST ORNITHOLOGIST
ECORD. DOUBTLESS HE HAD PREDECESSORS, BUT FOR
FOLLOWING NEARLY 2000 YEARS HE HAD NO COM-
LE SUCCESSORS. THE OUTSTANDING ORNITHOLOGICAL
MARKS DURING THIS PERIOD WERE THE WORKS OF
OMBY AND RAY (1676), EDWARDS (1743), BUFFON
, LINNAEUS (1758), BRISSON (1760).
N AMERICA, CATESBY'S 'NATURAL HISTORY OF SOUTH

CAROLINA' (1731-1743) WAS THE FIRST MAJOR WORK ON BIRDS. IT WAS FOLLOWED BY PENNANT'S 'ARCTIC ZOOLOGY' (1784-1787) BUT THE EARLIEST ATTEMPT AT A COMPLETE NORTH AMERICAN ORNITHOLOGY WAS THAT OF ALEXANDER WILSON (1808-1814), SINCE CALLED "FATHER OF AMERICAN ORNITHOLOGY." WILSON'S WORK LAID THE FOUNDATION FOR AUDUBON'S INCOMPARABLE 'BIRDS OF AMERICA' (1827-1839) WHICH EXERTED AN

IMMEASURABLE INFLUENCE ON THE STUDY OF BI
BIRD STUDENTS AND WORKS ON AMERICAN BIRDS
BAIRD, CASSIN, COUES, RIDGWAY AND OTH
HAVE STEADILY INCREASED IN NUMBERS, LEADI
IN 1884, TO THE FOUNDING OF THE AMERICAN ORN
OLOGISTS' UNION. THIS ORGANIZATION GAVE B
TO THE AUDUBON SOCIETY AND STILL WIDELY PROMO
THE STUDY AND CONSERVATION OF BIRDS.









V. GANNETS. Modeled by Thomas Famiglietti.

SECTION V

BIRDS IN ART

In addition to their manifold claims on the artist, the designer and decorator, birds doubtless receive more attention from the illustrator than any other forms of wild life. Such illustrations may rank high as art, nevertheless they are made primarily to accompany text in either book or portfolio. The author, therefore, both popular or scientific, is an effective promoter of bird art.

It is the crude outlines of birds in the caves of France and Spain that are our oldest records of man's contact with birds. They were made, it is said, about 15,000 years ago.

Compare them with our next exhibit, the geese of Medum, Egypt. Here, as far as art is concerned, we have the difference between savagery and civilization. In time, if our chronology is approximately correct, the cave drawings are 12,000 years the older.

Whether the creator of the goose mural was an Audubon or a Fuertes of his time, or whether he merely represented the average bird painter, is unknown. But certain it is that his work is comparable with that of the best bird muralists of our own day.

Our specimens of the work of America's two greatest bird artists show them as illustrators; Audubon, by a slightly reduced reproduction of the Carolina Paroquet plate in his *Birds of North America*. Fuertes, by the original water-color of European Starlings, made by him to serve as the frontispiece of the latest (1903) edition of Coues' *Key*. It is shown as printed in a copy of this work at the bottom of the preceding section. The discriminating critic will, we believe, find the character of each artist reflected in his work.

The paintings of the great Swedish bird artist, Liljefors, were pure art untrammelled by the needs or restrictions of science. Our example is from *Ute I Markerna*. Frank W. Benson has presented us with an etching in a field he has made his own, and we conclude this brief exhibit with a drawing characteristic of the Japanese school.

Lovers of bird art will find exhibits of the work of Louis Fuertes and of Joseph Wolf in the gallery of bird paintings on the 4th floor, Whitney Wing.

Sculptors have not drawn widely on birds as subjects and we are therefore privileged to demonstrate the possibilities in this field by the "Gannets" of Thomas Famiglietti, formerly of the Museum staff.

References

1933. Sutton, G. M. Fifty Years of Progress in American Bird-Art. (Fifty Years Progress in American Ornithology, Amer. Orn. Union.)

1942. Peterson, Roger T. Bird Painting in America. Audubon Magazine, Vol. XLIV, No. 3, May-June, pp. 166-176.

Section VI

ECONOMIC ORNITHOLOGY I

THE FOOD OF BIRDS

Economic Ornithology treats of the ways in which birds affect the food-supply, health and financial resources of man. These ways are so numerous, so varied, and so contradictory that the status of any bird can be determined only by a study of its habits throughout its range and at all seasons.

Man, the agriculturist, exhibits so great an influence on his environment that wherever he exercises his potentialities he creates a world of his own. His relations to birds, therefore, should always be viewed in the light of conditions for which he himself is largely responsible.

Section V

BIRDS IN ART

(See opposite page)

Drawings of Caveman.

Drawings of Caveman.

These outlines are from Salomon Reinach's "Repertoire de l'Art Quaternaire" (1913).

The Geese of Medum, Egypt, 3000 B.C. White-fronted, Bean and Red-breasted Geese. The original is in the Museum at Cairo. A facsimile is in the Metropolitan Museum of Art, N. Y.

Carolina Paroquets.
Reduced from Audubon.

European Starlings.
Fuertes' frontispiece for Coues' "Key" (See Section IV).

Swans.
By Bruno Lijefors. From his "Ute I Markerna."

Mallards.
Etching by Frank W. Benson.
Presented by Artist.

Goshawk.

Japanese Print.

Gannets.
Thomas Famiglietti.

BIRDS IN ART



THE FIRST KNOWN BIRD DRAWINGS ARE THE CRUDE OUTLINES MADE ABOUT 15,000 B.C. BY THE CAVEMEN OF SOUTHERN FRANCE AND NORTHERN SPAIN ON THE WALLS OF THEIR DWELLINGS. BY 3000 B.C. BIRD ART HAD REACHED A DEGREE OF PERFECTION SHOWN BY THE BEAUTIFUL MURAL OF THE MEIDUM GEESE AND OTHER EARLY EGYPTIAN PAINTINGS. THIS STAGE OF DEVELOPMENT WAS NOT AGAIN APPROACHED UNTIL THE TIME OF AUDUBON, 4600 YEARS LATER.

BIRD ART HAS FOUND ITS WIDEST OPPORTUNITY FOR EXPRESSION IN ILLUSTRATING WORKS ON ORNITHOLOGY. SUCH ILLUSTRATIONS MAY VARY FROM A PEN-AND-INK OUTLINE TO PAINTINGS BY AN AUDUBON OR A RUSKIN. IN ANY CASE ACCURACY IS ESSENTIAL.

APART FROM FROM FILLING THE NEEDS OF SCIENCE, BIRDS BEAUTY, GRACE OF FORM AND MOTION MAKE THEIR OWN APPEAL TO THE [illegible]

IN COUNTLESS WAYS BIRDS ALSO SERVE THE DESIGNER AND DECORATOR WHOSE SKILLFUL EMPLOYMENT OF HERON AND CRANE MOTIF GIVE CHARM TO SCREEN OR MURAL













This means a study as wide as the birds' range and as endless as the constantly changing activities of man. His alteration of the character of the country, planting of new crops, introduction of foreign species, all produce new ecologic conditions calling for constant study of the native fauna.

This situation cannot be easily treated in a museum exhibition, so we have selected the Food of Birds as a subject in which we can illustrate the greatest service birds render man. From the ranks of the Insect-, Seed- and Rodent-eaters and the scavengers we have chosen small representative groups to show the nature of their food and method of securing it. The air-feeders include both nocturnal as well as diurnal birds; Swallows, Swifts, and Nighthawks among the latter, the Whip-poor-will and Chuck-wills-widow among the former. All are almost exclusively insectivorous.

The Redstart is a good connecting link between those birds that feed wholly on the wing and those that, like Flycatchers, make sallies from a perch to which they return.

Vireos, Warblers, Thrushes and Wrens are gleaners from tree-top to earth and are particularly valuable in our gardens, a favorite resort for insects. If some of them add fruit to their fare they probably have earned it.

The seed-eaters, Sparrows, Goldfinch, Cardinal and many other members of the great Finch family, perform a service of incalculable value in destroying seeds of weeds that follow in the wake of cultivation. In "Useful Birds" Forbush lists 41 kinds of noxious seeds eaten by birds.

When we say "Rodents" we usually mean rats and mice, meaning chiefly the foreign species, for the presence of which man is responsible. But neither Hawks nor Owls ask the nativity of their prey. They take what they find and if they are hunting in man's haunts they are apt to capture the species that are more or less parasitic on man. Farther afield they may get a larger proportion of native species; but all are destructive unless held in balance by nature's means.

There is a widespread prejudice against Hawks and Owls, but if we except the Great Horned Owl, Cooper's and the Sharp-shinned Hawk, we are safe in accepting the remaining commoner members of these families as friends rather than as foes.

The food of most water-frequenting birds is somewhat beyond our present limits but the Gulls, scavenging along our coasts, take the edible refuse from our shores and waters; while the Black Vulture and Turkey Buzzard are equally valuable on the land. The impossibility of presenting here anything like an adequate exhibit showing the economic relations of birds and man is obvious. It is hoped, how-

ever, that some conception of the extent and importance of the subject may be gained from the appended summary.

ECONOMIC RELATIONS OF BIRDS TO MAN

A. *Beneficial Relations.*

Feeding on injurious insects, seeds and rodents; scavenging.
Pollination of plants.

B. *Harmful Relations.*

Destructive to grains, crops, fruits.
Destroyers of beneficial insects and birds, fowls.
Devourers of fish, chiefly in hatcheries.
Distributors of disease-bearing parasites.

ECONOMIC RELATIONS OF MAN TO BIRDS

A. *Beneficial Relations.*

(a) Intentional

Protection by law and creation of a conserving sentiment: bird study in schools and colleges.
Enlarging and improving all-season habitats; increasing food supply.
Creation of refuges.
Preparing nesting-sites and boxes; maintaining feeding stations and baths.
Organized study of ecology.
Development of domestic breeds.

(b) Unintentional

Planting crops and raising fruit on which birds feed.
Leaving undergrowth that may serve for nesting sites, shelter and food.
Irrigation; parks; lawns.
Garbage dumps.
Destruction of predatory birds and mammals.

B. *Harmful Relations.*

(a) Intentional

Killing for flesh or feathers for self-use or sale, or for other reasons.
Killing for sport.
Killing in defense of crops, etc.
Trapping.
Egging.

Section VI

ECONOMIC ORNITHOLOGY I

(See opposite page)

Barn Swallow.

Chimney Swift.

Redstart.

White-breasted Nuthatch.

Red-eyed Vireo

Downy Woodpecker.

Yellow-billed Cuckoo.

Flicker.

Tree Sparrow.

Red-shouldered Hawk.

Goldfinch.

Screech Owl.

Cardinal.

Black Vulture.

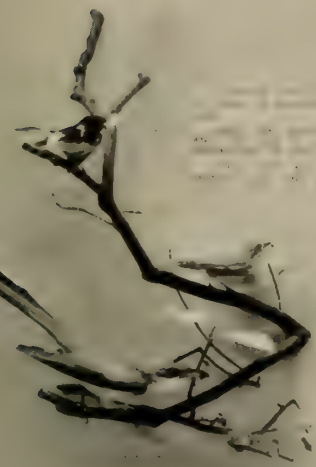
Herring Gull.

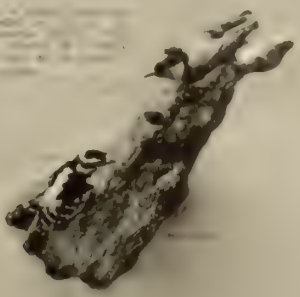
ECONOMIC ORNITHOLOGY I



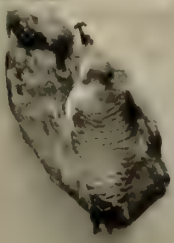


THE FOOD OF BIRDS



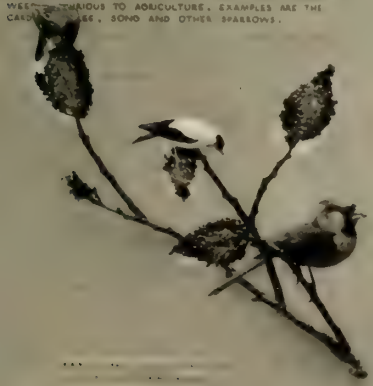


THE INSECT EATERS



THE SEED EATERS

THE BILLS OF SPARROWS AND OTHER HARD-BILLED BIRDS SERVE AS CRACKERS OR CRUSHERS AND ENABLE THESE BIRDS TO FEED ON SEEDS WHICH MIGHT PRODUCE WEEDS [illegible] INIMICAL TO AGRICULTURE. EXAMPLES ARE THE CARDINAL, SONG AND OTHER SPARROWS.



THE RODENT EATERS

RATS, MICE AND OTHER NOXIOUS SMALL RODENTS ARE DESTROYED BY OWLS AND HAWKS AND SOME OTHER BIRDS.





THE SCAVENGERS

WHERE MAN HAS NOT DEVELOPED EFFECTIVE METHODS OF GARBAGE DISPOSAL, SCAVENGERS, LIKE VULTURES AND GULLS, RENDER HIM VALUABLE SERVICE. EXAMPLES ARE THE BLACK VULTURE, TURKEY BUZZARD AND HERRING GULL.



(b) Unintentional

Increasing human population, new settlements, with consequences.

Alteration of haunts by deforestation, drainage, stream pollution, discharge of oil on coastal waters.

Use of poisons for insects or rodents, etc.

Predatory house cats; rats.

Introduction of competing birds; sparrows; starlings.

Erection of obstructions to flight.

References

1907. Forbush, E. H. Useful Birds and Their Protection. (Massachusetts Board of Agriculture.)

1927. Henderson, J. The Practical Value of Birds (Macmillan).

1933. Storer, T. I. Relations Between Man and Birds in California. The Condor, pp. 55-59.

Section VII

ECONOMIC ORNITHOLOGY II

DOMESTICATION

It is not improbable that the domestication of birds began when man first established a permanent home for himself. He could then care for an injured or young bird that chanced to come into his possession. If the bird accepted human association and became, as it were, a member of the family, the first stage in its domestication was passed. But there was a limit to man's hospitality. Birds that were wholly dependent on him for food were less desirable than those that in part, at least, could care for themselves. A chicken, for example, might scratch up a living about its home, or a duck might seek its fare in the mud and waters of a neighboring marsh, while both could find protection near man for the night. Their habitat and food were thus so natural that they mated with other individuals of their kind, tame or wild, and produced young which accepted as normal their parents' association with man. This is the second stage in our possible history of domestication. As further requirements the bird should be big enough for both its body and eggs to make a worth while source of food, and it should be fecund. If its feathers were useful, so much the better, but this was not indispensable.

These are the elements of successful domestication in the country of which the bird is a native. But to fulfill all the possibilities of domestication the bird should be prepared to live in any part of the world inhabited by man.

It is a common experience to see, for example, Chachalacas, Guans and Tree Ducks in their own land as tame as barnyard fowls; but they would not stand climatic change and their economic value is therefore limited by the extent of their range.

When, therefore, we consider the essentials of temperament, edibility, fertility and adaptability that enter into the making of a wholly successful domesticated bird we discover that there are surprisingly few kinds of birds that possess them all. The Jungle Fowl, Lag Goose and Mallard from the Old World, the Musk Duck and Turkey from the New, are the only ancestral forms that really deserve a place on our list. Peafowls, Guinea Fowls and Swans are not to be classed with them. Pigeons hold a quite different relation to man. Let us briefly consider all these birds in the order named.

The Chicken. — The Chicken, or Barnyard Fowl, stands at the head of our list of domesticated birds. Descended from the Red Jungle Fowl *(Gallus bankiva)* of Eastern India, Burma, Siam and Sumatra, early home of the human race, it seems probable that the Chicken was the first bird to be domesticated by man.

The Chicken possesses in a highly developed degree all the essential qualifications of domestication. To them it adds a lust for fighting which has endeared it to man and may have played no small part in promoting its domestication. No other bird has the aggressiveness and courage of the game cock. No other sport has had a larger following than cockfighting. It is within range of both rich and poor and has at times exerted so wide and undesirable an influence that it has been suppressed or prohibited by law.

In view of the countless varieties of fowls that are believed to have originated from the Jungle Fowl, it is remarkable that the Game Fowl should still resemble its ancestor. But as much care has been taken to preserve its original characters as to develop and establish those of its promising variants. Wherever the hen is found there may appear mutants or "sports" from which new races are bred. Among the better known are the Brahmin and Cochin from Asia, the Leghorn from Italy, the Houdan from France, the Dorking and Orpington from England, the Plymouth Rock and Rhode Island Red from North America and, as late as 1914, the Araucana, a race of unknown origin, was discovered in Chile. It is rumpless, has eartufts, and lays blue eggs. Who knows whence the next new race will come?

Directed by the laws of inheritance which a study of Mendelism and genetics has revealed, we may now hasten the processes of nature by definitely directing them. So remarkable have been the results attending this type of applied ornithology that governments, state and agricultural colleges, now have thousands of students experimenting in

SECTION VII

ECONOMIC ORNITHOLOGY II

ANCESTRAL FORMS OF DOMESTIC BIRDS

(See opposite page)

Peacock.
India, including Ceylon, eastward through Malay Peninsula to Java.

Rock Dove.
A Typical Homing Pigeon. (The Homer is shown because of its importance.)
British Isles to North Africa, Burma and China.

Jungle Fowl.
(Cock and Hen.)
Indian-Malayan region.

Guinea Fowl.
Africa and Madagascar.

Mallard.
Northern Hemisphere.

Musk Duck.
Tropical America.

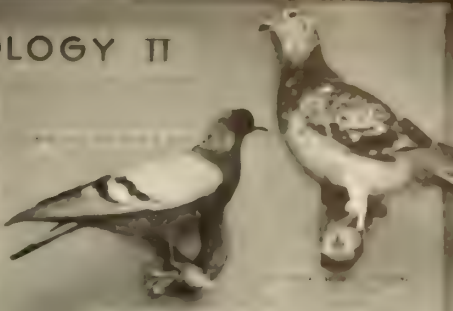
Grey-Lag Goose.
Northern Europe to Eastern Asia.

Mexican Turkey (Hen).
Mexican Tableland from Chihuahua to Colima.

ECONOMIC ORNITHOLOGY II

DOMESTICATION







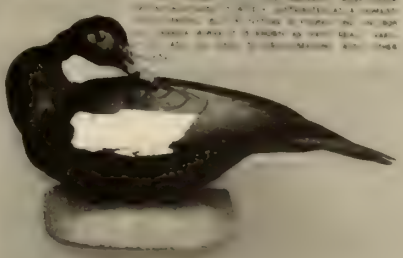


MALLARD

THE MALLARD (*ANAS PLATYRHYNCHOS*) INHABITS THE NORTHERN HEMISPHERE. ONLY TWO SUBSPECIES ARE KNOWN IN NATURE. THE DOMESTICATED MALLARD RESEMBLES ITS WILD ANCESTOR IN COLOR BUT IS HEAVIER AND DOES NOT FLY.

THE ROUEN, AYLESBURY, CALL, HOOKED-BILL, TUFTED, AND PEKINGIAN DUCKS ARE POSSIBLY MUTANTS OF THE DOMESTICATED MALLARD, WITH WHICH THEY INTERBREED. ALL HAVE CURLY-TIPPED CENTRAL TAIL FEATHERS.





GOOSE

THE WILD ANCESTOR OF THE DOMESTIC GOOSE IS THE GREY-LAG GOOSE (*ANSER ANSER*), AN OLD WORLD SPECIES WHICH, IN NATURE, NESTS FROM ICELAND TO EASTERN ASIA. THERE IS ONLY ONE FORM OF THE DOMESTIC RACE. IT VARIES IN COLOR FROM GRAY TO WHITE AND IS HEAVIER THAN THE WILD

TURKEY

FIVE RACES OF WILD TURKEY ARE KNOWN: EASTERN WILD TURKEY (*MELEAGRIS GALLOPAVO SILVESTRIS*), PENNSYLVANIA TO EASTERN TEXAS; 2 FLORIDA WILD TURKEY (*M. G. OSCEOLA*), SOUTHERN FLORIDA; 3 MERRIAM'S WILD TURKEY (*M. G. INTERMEDIA*), MIDDLE TEXAS TO NORTHEAST MEXICO; 4. MERRIAM'S WILD TURKEY (*M. G. MERRIAMI*), SOUTHERN COLORADO, NEW MEXICO, OF ARIZONA TO NORTHERN MEXICO; 5 MEXICAN WILD TURKEY (*M. G. GALLOPAVO*), MEXICAN TABLELAND FROM CHIHUAHUA TO COLIMA. THE

WILD BIRD IS DESCENDED FROM NO. 5. THE MEXICAN RACE. IT WAS FOUND DOMESTICATED BY THE EARLY SPANIARDS AND BY THEM [illegible] REACHED ENGLAND AS EARLY AS 1541 AND LATER WAS BROUGHT BY ENGLISH COLONISTS TO NORTH AMERICA. THE DOMESTIC BIRD HAS THE TAIL AND TAIL-COVERTS TIPPED WITH WHITE. IN THE EASTERN WILD BIRD THEY ARE [illegible] WHITE. [illegible] 3,167,000





well-equipped laboratories where comparatively few years ago only the commercial breeder was working blindly in the poultry yard. The marvel of today will soon be the commonplace of tomorrow, and it will in turn be succeeded by conditions we cannot even imagine. The United States has taken the lead in this practical biology. Already the annual value of the hen and its eggs is over a billion dollars, and H. R. Lewis, writing in the *National Geographic Magazine* for April 1927, states that poultry products rank sixth in our annual agricultural income, and if one may judge the future by the past, they will in due time take first place.

The hen owes much to her egg. In 1937, the U. S. Department of Agriculture tells us that the value of hens' eggs was double that of their flesh, and in view of the enormous increase in egg-laying production for which the breeders and raisers of hens are responsible, it seems probable that no small part of the hen's increase in value will be made as an egg-layer.

We see now the importance of having selected a fertile bird in the beginning. Assuming that the wild Jungle Fowl had two broods annually, it produced about 25 eggs yearly. Compare that with the exceptional record of a British Columbia hen that laid 351 eggs in 365 days and the possibilities of the future are apparent.

Goose. — There is a wide difference between the Gamecock and the Gander but they agree in accepting the conditions of domesticity imposed by life with man. That is, they will abandon the forest or marsh for the barnyard. The Goose is neither a fighter nor a fertile egg-layer, but it has a large body of highly edible flesh, it bears a quantity of valuable down and its quills long supplied the world with pens (Sec. III). Geese are herbivorous and may be driven to pasture by a gooseherd.

The Gray Lag Goose *(Anser anser)*, from which the Domestic Goose has descended, ranges from Iceland to Eastern Asia. If the possibility of human contacts are indicated by the extent of its distribution, it may have been domesticated at several places independently. There is but one race of Gray Lag in nature and the common domestic goose differs from its wild progenitor only in being larger, more fecund and locally whiter. Other forms of the domestic goose are the Toulouse, the Brown and the White Chinese, the Embden and Gray African. There is a domesticated descendant of the Egyptian goose *(Chenalopex aegyptiacus)* which is found in Europe, north to Scotland. It resembles its ancestor.

The Canada Goose *(Branta canadensis)* seems to be on its way to complete domestication but at present it lives with man sporadically and is raised chiefly for parks and as decoys. It crosses with the Gray

Lag. The wild form is somewhat variable, several races being known. The tame bird resembles its ancestor.

Mallard. — The Mallard *(Anas platyrhynchos)*, most widespread of ducks, inhabits the greater part of the Northern Hemisphere, southward in winter, in the Old World, to India, in the New, to Panama. The Mallard readily associates with man, and in a few generations a maimed wild bird will become too heavy to fly and will join other ducks in the barnyard. In a sense, therefore, we see domestication taking place before our eyes.

In spite of its great range, the Mallard is a remarkably stable bird. In nature, only two races are known. Under the varying conditions of domestication, however, it has given rise to a number of birds and varieties including the Runner, Aylesbury, Rouen, Penguin, Buff and Pekin. The latter, an all-white duck, was introduced into the United States from Shanghai in 1873 and is now widely raised here. In all descendants of the Mallard, the drake has the four recurved tail-coverts shown by the parent species.

It is said that the wild Mallard is monogamous, while the tame Mallard is polygamous, a change in habits possibly due to the more crowded life of the barnyard.

The Mallard is prolific and is therefore of value to man, not only for its flesh but also for its eggs.

The Musk Duck *(Cairina moschata)*, miscalled Muscovy Duck, *Pato Real* of the natives, is found in the American Tropical Zone from northern Tamaulipas, Mexico, south to central Argentina. There is but one race in nature. It is a tree-inhabiting duck but in domestication loses the power of flight and becomes terrestrial. The Musk Duck differs from the Mallard in having a bare space about the eye, no recurved tail-coverts, and it does not quack; nevertheless, it hybridizes with the Mallard, a fact that doubtless accounts for the number of variations it shows when domesticated.

Turkey. — Cortez found the domesticated Turkey *(Meleagris gallopavo gallopavo)* in the possession of the Aztecs, and the specimens of it that he sent back to Spain have proved to be of greater value to the world than all the other treasure he secured in Mexico. From Spain, the Turkey is said to have reached England as early as 1541. It soon became established in England and thence accompanied the colonists to New England to serve as food on the voyage and in their new homes.

This, in outline, is the story of the introduction of the domesticated Turkey into the United States. But the history is far from complete. At the time the Mexican bird reached this country from England the Eastern Wild Turkey was a common bird in the Eastern United States as far north as southern Maine. So far as we know, it had not been

domesticated, and it was the bird brought from England that the colonists put in their poultry yards. There its descendants remain, but the Wild Turkey is now extinct in New England, indeed is not found north of central Pennsylvania and only locally southward.

Fortunately for the student of their history, the Mexican Wild Turkey and the Eastern Wild Turkey differ in color from each other enough to be distinguished at sight. The Mexican bird and its domesticated descendants have the tips of the tail and of the tail-coverts whitish (see the female in the group and photograph) while in the Eastern Wild Turkey these parts are chestnut. But as we go from one country to the other we find that these characters gradually change and the two extremes are connected by intergrades; a good example of subspecific geographic variation. Thus, beginning at the South, we have: (1) Mexican Wild Turkey *(Meleagris gallopavo gallopavo)*, Mexican Tableland from Colima to Chihuahua. This is the ancestral race. (2) Moore's Wild Turkey *(M. g. onusta)*, western slopes of the Sierra Madre in southeastern Sonora and Sinaloa. (3) Merriam's Wild Turkey *(M. g. merriami)*, southern Colorado to mountains of Arizona and northern Mexico. (4) Sennett's Wild Turkey *(M. g. intermedia)*, middle Texas to northeastern Mexico. (5) Florida Wild Turkey *(M. g. osceola)*, southern Florida. (6) Eastern Wild Turkey *(M. g. silvestris)*, eastern Texas and northern Florida, locally, to central Pennsylvania.

In domestication, Turkeys vary in color from black to white, six varieties being recognized. At present the experimental Bureaus of the United States Department of Agriculture are breeding a turkey small enough to be roasted in the average apartment-house oven. According to this Department, on January 1, 1940, there were 8,567,000 turkeys on our farms, valued at $18,679,000.

Peacock. — Peacocks are found from India, including Ceylon, eastward through the Malay Peninsula to Java. There are two species, *Pavo cristatus* and *P. muticus*. The former is the more common and is the ancestor of our lawn bird. A mutant race of *P. cristatus*, called *Pavo nigripennis*, appears only in domestication and may at times revert to the parent stock. White individuals occasionally occur.

The Peacock does not take well to domestication. It seems to consider itself superior to the usual barnyard fowl; moreover it is not fertile. Doubtless, without the attractions of its marvellous plumes, it would not have found its way with man.

The Peacock and Jungle Fowl are natives of the same region where they both have doubtless been associated with man from the period of their domestication. The former is chiefly ornamental and has a limited place in man's economy. The latter is the most valuable animal in the world. Nevertheless, the Peacock, and not the fowl, is mentioned

in the Old Testament and as the bird of Juno it had a place in Grecian mythology that the humble fowl was not given.

If the Peacock's tongue formed part of Roman feasts, it was evidently display of wealth rather than palatability that gave it a place as food.

Guinea Fowl. — The Guinea Fowl is said to have descended from *Numida meleagris* of west central Africa. Although there are 21 races of this bird extending eastward to Madagascar, the domesticated bird shows but little variation, a tendency to whiteness being its principal change from its ancestor.

The Guinea Fowl never becomes thoroughly familiar with man and its excited cry of alarm when disturbed is a familiar note. Where the surroundings are favorable, it is apt to run wild. Then it is hunted as a game bird.

Pigeon. — Darwin's belief that the Rock Pigeon *(Columba livia)* is the ancestor of the Domestic Pigeon and its many breeds and varieties is still the prevailing opinion. This fine bird, represented by 14 subspecies, ranges from Great Britain south to northern Africa east to China. In spite of the countless races to which it has given rise, individuals that essentially resemble the parent form are still frequently found among our domestic birds.

Aside from its distinguished place in the past, the Pigeon of today holds increasingly important relations with man. To the pigeon fancier the bird gives a hobby or occupation of world-wide interest with the development of the Homing Pigeon as its outstanding achievement. Signals, telegraph, telephone, radio yield more and more effective service, but the Homer still fills a unique place as a means of communication among men. Both adult and young Pigeons occupy growing space in our markets. In the laboratory the birds are the faithful servants of research.

But comparatively few of us know much about variation and inheritance, artificial selection and breeding, or the raising of squabs, and fewer still conduct experiments in genetics. But we all see the pigeons of our parks and the cliffs of our skyscrapers who own no master. They are really worth more to man than those of all the other classes combined. They come to our window sills, feed on the lawns at our feet, or perch on our hands or shoulders. They are free to come and go, or to fly for the joy of flying, but their confidence in us makes them part of our lives.

The earthbound mind may protest against the use of our walls and roofs and the crevices that architects have so fortunately, but so unwittingly provided, but to him who rejoices in the birds' sweeping

circles overhead and lightning flashes past our windows, their wings spell freedom.

References

1868. Darwin, C. The Variation of Animals and Plants Under Domestication. 2 vols. John Murray, London.

1927. Jull, Morley A. The Races of Domestic Fowl. 96 illus., 29 in color. Nat. Geog. Mag., Vol. 51, No. 4, April, pp. 379-452.

Lewis, Harry R. America's Debt to the Hen. 15 illus. Nat. Geog. Mag., Vol. 51, No. 4, April, pp. 453-467.

1930. Jull, Morley A. Fowls of Forest and Stream Tamed by Man. 43 illus., 16 colored. Nat. Geog. Mag., Vol. 57, No. 3, March, pp. 327-371.

1941. Levi, W. M. The Pigeon. R. L. Bryan, Columbia, S. C. Indispensable to the pigeon-minded.

Section VIII

ECONOMIC ORNITHOLOGY III

In this section we have placed facts and feathers which bear little or no relation to one another but are closely related to man.

Flight. — It may be argued that man never would have flown without the example of birds to stimulate his imagination and arouse his ambition. Certain it is that the earlier aëronauts took the birds as a model. Lilienthal lost his life in the attempt to fly like a bird. The subject of birds' flight will be treated elsewhere in this hall, but we pause here to pay a tribute to him as one of a band of fearless adventurers who tried to conquer the air.

The Feather Trade. — From the beginning of their contact with man birds have been cursed by their flesh and their feathers. The former was perishable and the market correspondingly restricted. The latter are light, easily transportable, long-lived. They could be safely sent from the most remote parts of the earth. From milliner to hunter, the trade was strongly organized. Paradise plumes were fashionable in London and in New Guinea; aigrettes were the mode in Paris and on the Orinoco. The birds of our gardens were not spared.

Perhaps in no other one way can our change of heart toward birds be more convincingly shown than by comparing the trimming of the hats of today with those of over fifty years ago. Here is a list of the species of birds I saw on women's hats in 1885 on Fourteenth Street, then the shopping district of New York.

Robin, four
Brown Thrasher, one
Bluebird, three
Blackburnian Warbler, one
Blackpoll Warbler, three
Swallow-tailed Flycatcher, one

Kingbird, one
Kingfisher, one
Pileated Woodpecker, one
Red-headed Woodpecker, two
Wilson's Warbler, three
Scarlet Tanager, three
Tree Swallow, one
Bohemian Waxwing, one
Cedar Waxwing, twenty-three
Northern Shrike, one
Pine Grosbeak, one
Snow Bunting, fifteen
Tree Sparrow, two
White-throated Sparrow, one
Bobolink, one
Meadowlark, two
Baltimore Oriole, nine
Purple Grackle, five
Blue Jay, five
Flicker, twenty-one
Saw-whet Owl, one
Mourning Dove, one
Prairie Hen, one
Ruffed Grouse, two
Bob-white, sixteen
California Valley Quail, two
Sanderling, five
Greater Yellowlegs, one
Green Heron, one
Virginia Rail, one
Laughing Gull, one
Common Tern, twenty-one
Black Tern, one
Grebe, seven

Today, if you can find one of these on a hat in any shopping district in this city or elsewhere, and can name the offender, I am sure that the Audubon Society will arrest her and reward you.

In America, organized bird study was the first step in the control of the feather trade. You cannot arouse support for a cause that is only a name. On September 26, 1883, the American Ornithologists' Union was formed. Two years later it gave birth to the first Audubon Society. From that seed have grown the flourishing conditions of today.

Condor. — Recently there was an attempt to revive the fashion of wearing large quills, among them those of the Condor. It was quickly suppressed by the Audubon Society.

Some years ago a Condor hunter, whom I met in Mendoza, Argentina, at the foot of the Andes, told me that he had sent the wings and tails of 16,000 Condors to milliners in Paris. For them he had received twenty dollars gold per bird. Because of the war, the price had fallen to ten dollars per bird. This fact thoroughly aroused the hunter's indignation and with fine dramatic display he said, "I refuse to take part in the destruction of such a noble bird for such a low price!"

Swan. — Powder-puffs are in themselves harmless things but countless swans have been killed to supply them. A Museum man reports finding the skins of hundreds of thousands of Black-necked Swans awaiting shipment in an Argentine warehouse.

The Rhea as a Feather Duster. — A Rhea that gives its life to prevent a Tehuelche from starving, dies a not unworthy death (Sect. I); but a Rhea that is killed to make a feather duster is shamelessly sacri-

SECTION VIII

ECONOMIC ORNITHOLOGY III

(See opposite page)

Otto Lilienthal.
Born, 1848; Died, 1896.

Egret plumes still attached to the skin.

Bird of Paradise.

Condor Wing Quill.

Powder Puff.

Fish "Flies."

New Hebrides Money.

Feather-duster.

Egger on Bempton Cliff.
(Man at end of rope in middle of picture.)

Murre's Egg.

Chilean Pelicans nesting on island off Peru.

Tame and Wild Canary.

Fishing with Cormorants.

Guano Fleet off Chincha Is., Peru, in 1860.

Gray Partridge.

Starling.

House Sparrow.

Ring-necked Pheasant.
(Female and Male.)

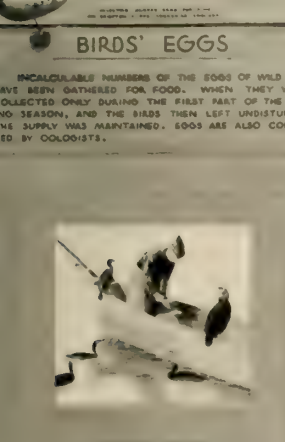
ECONOMIC ORNITHOLOGY III



CONDOR WING QUILL

BIRDS' EGGS

INCALCULABLE NUMBERS OF THE EGGS OF WILD BIRDS HAVE BEEN GATHERED FOR FOOD. WHEN THEY WERE COLLECTED ONLY DURING THE FIRST PART OF THE LAYING SEASON, AND THE BIRDS THEN LEFT UNDISTURBED, THE SUPPLY WAS MAINTAINED. EGGS ARE ALSO COLLECTED BY OOLOGISTS.

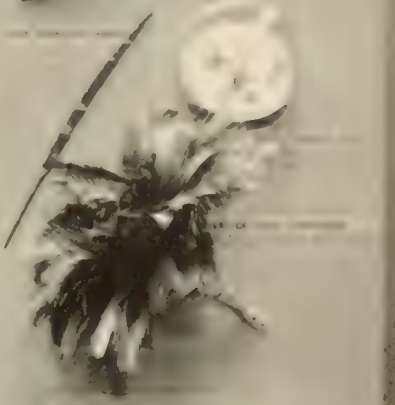


FISHING WITH CORMORANTS

IN CHINA AND JAPAN CORMORANTS ARE USED TO CATCH FISH. THE BIRD IS HELD CAPTIVE BY A LEASH AND A BAND AROUND ITS NECK PREVENTS IT FROM SWALLOWING THE LARGER FISH.





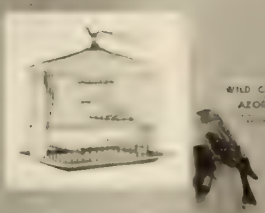




GUANO

OCEANIC ISLANDS IN RAINLESS AREAS MAY SERVE AS THE HOME OF CERTAIN SEA-BIRDS, FEEDING ON FISH. THEY TRANSFORM IT INTO FERTILIZER. THE MOST FAVORABLE CONDITIONS FOR THE PRODUCTION OF THIS GUANO EXIST OFF THE COAST OF PERU. THE BIRDS THAT PRODUCE IT ARE CORMORANT, BOOBY AND PELICAN. THE AVERAGE VALUE OF THEIR YEARLY DEPOSIT IS OVER SEVEN MILLION DOLLARS. THE TOTAL VALUE OF THE GUANO MINED THERE, INCLUDING THE ORIGINAL DEPOSIT, IS ABOUT ONE BILLION DOLLARS.





WILD CANARY AZORES

BIRDS AS PETS

BIRDS' VOCAL GIFTS, BEAUTY, FRIENDLINESS AND VITALITY CREATE A UNIVERSAL DESIRE FOR THEIR COMPANIONSHIP. FROM THE MOST PRIMITIVE TO THE MOST CIVILIZED MAN BIRDS ARE, THEREFORE, VALUED AS PETS. WHEN THEIR TEMPERAMENT AND SURROUNDINGS PERMIT, THEY MAY BE FREE; BUT IN MOST INSTANCES THE NEED FOR CONFINEMENT AND PROTECTION COMPELS THE USE OF A CAGE. THIS MAY HOUSE ONLY ONE BIRD OR THE TEEMING LIFE OF AN AVIARY.

THE INCREASING DEMAND, BOTH LOCAL AND FOREIGN, FOR MOCKINGBIRDS, CARDINALS AND OTHER AMERICAN BIRDS AS PETS, RESULTED IN THE PASSAGE OF A LAW PROHIBITING THEIR CAPTURE. IN THIS COUNTRY, THEREFORE, ONLY FOREIGN BIRDS MAY BE LEGALLY CAGED. WITH THEM IS INCLUDED THE SEMI-DOMESTICATED CANARY OF WHICH, IN 1920, WE IMPORTED 389,281. BELIEVED TO HAVE BEEN INTRODUCED INTO EUROPE FROM THE CANARY ISLANDS ABOUT 1500, BIRD-BREEDERS HAVE SINCE DEVELOPED MANY VARIETIES.

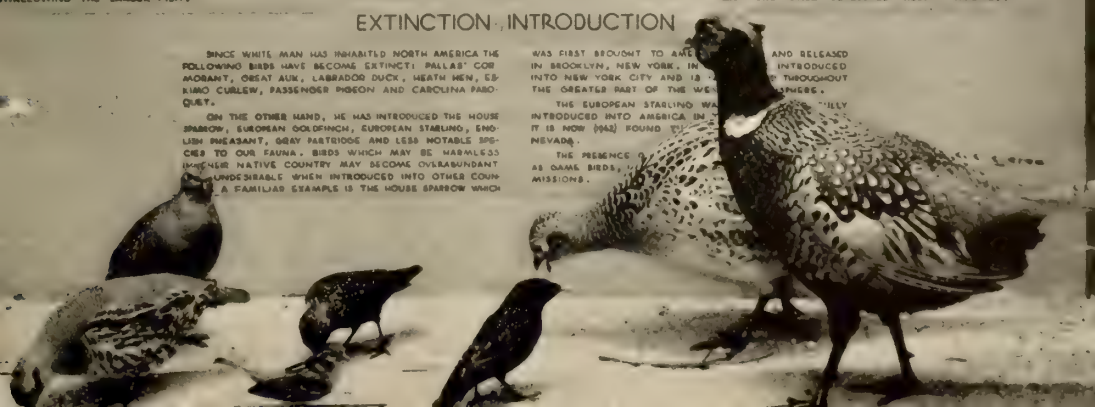
EXTINCTION, INTRODUCTION

SINCE WHITE MAN HAS INHABITED NORTH AMERICA THE FOLLOWING BIRDS HAVE BECOME EXTINCT: PALLAS' CORMORANT, GREAT AUK, LABRADOR DUCK, HEATH HEN, ESKIMO CURLEW, PASSENGER PIGEON AND CAROLINA PARAQUET.

ON THE OTHER HAND, MAN HAS INTRODUCED THE HOUSE SPARROW, EUROPEAN GOLDFINCH, EUROPEAN STARLING, ENGLISH PHEASANT, GRAY PARTRIDGE AND LESS NOTABLE SPECIES TO OUR FAUNA. BIRDS WHICH MAY BE HARMLESS IN THEIR NATIVE COUNTRY MAY BECOME OVERABUNDANT AND UNDESIRABLE WHEN INTRODUCED INTO OTHER COUNTRIES. A FAMILIAR EXAMPLE IS THE HOUSE SPARROW WHICH WAS FIRST BROUGHT TO AMERICA AND RELEASED IN BROOKLYN, NEW YORK. IN [illegible] INTRODUCED INTO NEW YORK CITY AND IS [illegible] THROUGHOUT THE GREATER PART OF THE WESTERN HEMISPHERE.

THE EUROPEAN STARLING WAS [illegible] INTRODUCED INTO AMERICA IN [illegible] IT IS NOW (1922) ROUND [illegible] NEVADA.

THE PRESENCE [illegible] AS GAME BIRDS, [illegible] MISSIONS.



ficed for an ignoble purpose. The extent of the trade in Rhea feathers threatens the bird's extinction. Sixty tons of them were found in a single Buenos Aires warehouse, bound for New York, by a museum representative.

It appears that in the Argentine the Rhea is called "Avestruz" or Ostrich, and as our laws permit the importation of Ostrich plumage, no way has yet been discovered to prevent the entrance of Rhea feathers into this country.

Birds' Eggs. — Man has levied not alone on domesticated, but on wild birds for their eggs. Murres, Gulls and Terns that nest in colonies are most often preyed on. If the eggs are gathered only during the early part of the laying season and the birds are then unmolested, no harm may be done and a natural asset is wisely used. But when Gulls are present in numbers they rob the exposed nests of other birds without regard to season and with disastrous results. In this way the Murres of the Farallone Islands, that once supplied San Francisco with eggs, have been driven from the islands.

Guano. — Certain sea birds living on oceanic islands feed on fish and transform it into guano, the fertilizing properties of which are retained in rainless areas. The most notable examples of these conditions are found on islets in the Humboldt Current off the coast of Peru. There, the annual deposit of countless Cormorants, Boobies and Pelicans, wards of the Peruvian Government, is valued at over seven millions of dollars. It is estimated that the value of the entire deposit found there is about one billion dollars.

Fishing with Cormorants. — In both China and Japan fish form a staple diet and Cormorants are employed for their capture.

The bird is held captive by a leash but is given sufficient freedom to pursue its game. A band or ring around its neck permits it to swallow only its smaller prey. This custom was at one time followed in England.

Birds as Pets. — Birds' vocal gifts, beauty, friendliness and vitality create a universal desire for their companionship. From the most primitive, to the most civilized man birds are therefore valued as pets. When their temperament and surroundings permit, they may be free, but in most instances the need for confinement and protection compels the use of a cage. It may contain only one bird or the swarming life of an aviary.

The growing demand, local and foreign, for Mockingbirds, Cardinals and other American birds as pets, resulted in the passage of a law prohibiting their capture. In this country, therefore, only foreign birds may be legally caged. First among them is the Canary of which, in 1920, we imported, chiefly from Germany, 589,251 individuals. Be-

lieved to have been introduced into Europe from the Canary Islands about 1550, breeders have since developed many varieties.

Extinction: Introduction. — During the past century the following North American birds have become extinct: Great Auk, Labrador Duck, Guadalupe Caracara, Heath Hen, Eskimo Curlew, Passenger Pigeon and Carolina Paroquet. The Whooping Crane, Ivory-billed Woodpecker and several others are near extinction.

The conservationist arrived on the scene at too late a date to save any of the first seven of these birds; it is doubtful if he can preserve the last two. But he has learned of the diverse dangers to wild life that follow in man's wake. Not the least among them is the introduction of foreign species.

Fortunately, we have passed the day when everyone was free to introduce any bird that he pleased. The well-meaning philanthropist who, in 1864, released House Sparrows in Madison Square, New York City, continued to import foreign birds to the end of his life. Skylarks, European Goldfinches, Chaffinches and Song Thrushes were among his attempts to add to our bird-life. The Lark lived for a time and we still see an occasional Goldfinch. But it was not until 1890, when the importer had 60 Starlings freed in Central Park, that he laid the foundation for what he considered his second great success.

One must indeed be an enthusiastic bird-lover to find much that is admirable in the House Sparrow. But if the Starling were a native of this country and occupied its alloted place, I believe that it would be a popular bird. It is attractive in appearance, has interesting habits, has a musical and varied voice, is of some economic value and in the fall, when it spreads its scroll across the sky, it moves with marvellous precision. Thousands of birds act as one. There appears to be no leader; no note of command. How can we explain the community of feeling that controls them? It is a pure expression of *joie de vivre* which raises the industrious plotter to an ethereal realm where nationalities are unknown, and the glorious heritage of flight is the universal emblem of bird-life.

At present our attitude toward foreign species has so completely changed that it is more difficult for a bird than for a man to secure permission to enter this country. At the best, one cannot predict the part the newcomer will play. How can one tell what rivalries or disagreements it will arouse? Is there an unoccupied habitat awaiting it, or must it make one of its own at the expense of a native species?

There are no ready-made answers to these questions. "Yes" in one place may be "No" in another. Only an actual test will tell us whether we win or lose. In either event we should realize the risk that we are taking.

The English, or Ring-necked Pheasant *(Phasianus torquatus)*, has both foes and friends. The former claim that it is destructive to crops and an enemy to our native grouse. The latter say that its value as a game bird far outweighs any harm it may do. In any event, the removal of the laws that now protect it would effectively prevent its undue increase.

The much smaller European Partridge *(Perdix perdix)* has apparently found a favorable habitat in our plains and prairies and their grain-fields where, if desirable, its spread can always be controlled.

References

1917. Crandall, Lee S. Pets: Their History and Care. Illus. Henry Holt and Co., New York.

1926. Gudger, E. W. Fishing with the Cormorant in China. Amer. Nat., Vol. 60, pp. 5-41.

1929. Gudger, E. W. Fishing with the Cormorant in Japan. Scientific Monthly, Vol. 29, July, pp. 5-38.

1933. Leopold, Aldo. Game Management. Scribner's.

1936. Murphy, Robert Cushman. Oceanic Birds of South America. 2 vols. American Museum of Natural History. New York.

Section IX

THE SENTIMENT OF ORNITHOLOGY

The Song of Birds. – Birds exercise their greatest influence on the mind of man through their voice. It was their wild calls that reached the ear of savage man; it is their songs that stir our hearts today. How remarkable it is that the tiny syrinx of some inconspicuous, perhaps unseen, songster has the power to inspire the poets' noblest utterances! Poets, indeed, were the first ornithologists, as any anthology of bird verse proves. Long before the zoologist was describing and classifying, the poet was writing of the birds that he knew. Aristophanes preceded Aristotle; Shakespeare was nearly a century before Linnaeus. The naturalist's works are replaced by better ones. What the poet writes remains as he wrote it.

This section of our exhibit might well have followed Section IV, "Birds in Books." But it has been placed after, rather than before, "Economics" in order that we might end our review on a subject which we believe to express the highest relation between bird and man.

To the Hermit Thrush and Bobolink, shown under the Literature of Birds, we add here three more representative American songbirds,

the Mockingbird, Cardinal and Wood Thrush. Each one is a noted songster in his own right but when, some spring morning in the South, their voices are joined, one exclaims with Izaak Walton:

"Lord, what music hast Thou provided for the Saints in heaven, when Thou affordest bad men such music on earth?"

Bird Study and Conservation. — "Know your bird!" should be the motto of the bird conservationist. Before he ventures to apply the principles of his profession to the living bird he should have a thorough knowledge of it in its environment. This means not only its haunts but its neighbors. Few birds are wholly good and fewer still are wholly bad. It is for the conservationist to determine just where a bird stands in the economic scale and value him accordingly.

Here comes the need for education. The trained conservationist is a specialist to whom the legislator applies, or should apply, for expert advice before exercising his functions as a lawmaker. We begin, therefore, at the beginning and first learn our bird. This is the plan the Audubon Society (1006 Fifth Avenue) has long followed. Since 1911 it has enrolled over six million pupils in its Junior Bird Classes. From that start bird study has entered the colleges where courses have for years been given that prepare the student to serve either State or Federal Government as a professional conservationist.

The Friendship of Birds. — The window feeding-shelf makes a bond between bird and man that is valuable to them both. Birds' shyness prevents that close association which begets friendship, but when birds accept our hospitality and, as it were, break bread with us, then we have a feeling of intimacy with them that brings them definitely into our lives. Children, particularly, love to welcome birds and never tire of watching them; and the association thus begun lasts through the years.

Bird baths, especially in summer, may also be provided, and nesting-boxes will usually find tenants. The attractiveness of our gardens may also be increased by the proper kind of planting. There are many books that tell just how to do this.

The next step in making the world better for birds, and hence for man, is the bird sanctuary. Here we have a larger area, on selected ground, and exercise more complete control. In the adjoining hall of the Roosevelt Wing there is a Habitat Group of the Roosevelt Bird Sanctuary, established by the National Audubon Society at Oyster Bay, New York, in honor of a great bird-lover. Note particularly, at the left of the group, the original of a letter written by Colonel Roosevelt to the New York State Audubon Society in 1898 at the time of its foundation.

SECTION IX

THE SENTIMENT OF ORNITHOLOGY

(See opposite page)

Mockingbird. Cardinal. Wood Thrush.

Nuthatch.

Blue Jay. Downy Woodpecker.

Nuthatch.

Purple Finch Chickadee. Tree Sparrow. Junco.

Myrtle Warbler.

House Sparrow.

Bob-white. Junco.


THE SENTIMENT OF ORNITHOLO
OF BIRDS
AS THE POETS BECOME REALISTS, MAN
RECOGNIZES THE MOST ELOQUENT EXPRESSION OF
NATURE'S BEAUTY, JOY AND FREEDOM. IT WAS THEIR POWER
OF FLIGHT THAT STIMULATED HIS AMBITION TO MASTER THE
AIR. IT WAS THROUGH THEIR WILD CALLS THAT BIRDS CLAIMED
ATTENTION OF SAVAGE MAN; IT IS THROUGH THEIR SONGS THAT
THEY REACH OUR HEARTS TODAY
AND CONSERVATI
IS THE BASIS OF
SPIRED CONSERVATION
TS TO ATONE FOR HIS
DESTRUCTION OF NAT-
S AND TO AIME THE
E FOR THE LIFE
OM THE AUDUBON
FTH AVENUE) BEGAN
OR BIRD CLASSES IN
SINCE ENROLLED OVER
RLS. FROM THAT BEG-
UDY ENTERED THE
HERE COURSES ARE
WHICH PREPARE
TO SERVE EITHER
EDERAL GOVERN
A PROFESSIONA
NIST.
THE FRIENDSHIP OF
TO MAKE FRIENDS WITH TH
WE OFFER THEM NESTING
BATHING PLACES IN SUMME
IN WINTER PROVIDE THEM
FOOD AT OUR WINDOWS.
WITH OTHER BIRD LOVE
DEVELOP FAVORABLE AREA
BIRD SANCTUARIES: SUCH A
AMPLE, IS THE ROOSEVELT
SANCTUARY AT OYSTER BAY
FULLY REPRODUCED IN THE
HALL

LOOKING BACKWARD

Even in our own time there has been an almost unbelievable change in our relations to birds. Countless illustrations in proof of this statement will occur to every bird-lover. In my youth feeding-stands and bird baths were rare and interest in birds was largely limited to sportsmen and gunners. Primarily in their own behalf, they secured the passage of laws designed to protect game birds; "game laws" they were called, and game commissioners and game wardens were appointed to enforce them. Laws for the protection of song and insectivorous birds were as unknown as the birds themselves. These birds were shot at any season. Witness the list of hat birds in the preceding section. Compare the Quail in Sections I and IX.

Birds sang just as sweetly then as they do now, but we did not hear them. They were just as beautiful as they are today, but we did not see them. They were just as ready to make friends, but we did not heed them. It is man, not the birds, who has changed. The place that they have won in his life is a measure of his increasing awareness of his environment as birds have helped reveal it to him.

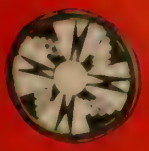
References

1916. Ladd, Neil Morrow. How to Make Friends With Birds. What to Do to Make One's Home Grounds Attractive to Bird Life. From Nesting Boxes to Winter Feeding. Doubleday, Page & Co.

1939. McKenny, Margaret. Birds in the Garden and How to Attract Them. Reynal & Hitchcock, New York.

1941. Baker, John H. (Editor). The Audubon Guide to Attracting Birds. Doubleday, Doran and Company.



The Archaeologist at work

How Science Deciphers Man's Past

By CLARK WISSLER



THE AMERICAN MUSEUM OF NATURAL HISTORY

MAN AND NATURE PUBLICATIONS

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By Clark Wissler

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HOW SCIENCE DE(

A rapid trip through the story of archaeology reveals how the Sherlock Holmeses of science have developed methods for solving the greatest mystery story of all

By CLARK WISSLER

Curator Emeritus, Anthropology, American Museum of Natural History

A SKILLED archaeologist is the Sherlock Holmes of anthropology. The uncanny use he can make of faint traces in the earth where unknown human beings once lived is more fascinating than detective fiction. We believe you will enjoy looking in upon archaeologists at work.

The archaeologist has confidence in his methods. Some of his basic articles of faith are given at left.

With these principles in mind, the archaeologist faces his job, which is to discover what types of community living have existed in the world, where they existed, and in what time order. If the reader can keep these simple statements in mind he should have little difficulty in understanding the remainder of this article and in interpreting the pictures.

↓ A 3400-year-old safety pin, of bronze



The Archaeologist's Articles of Faith

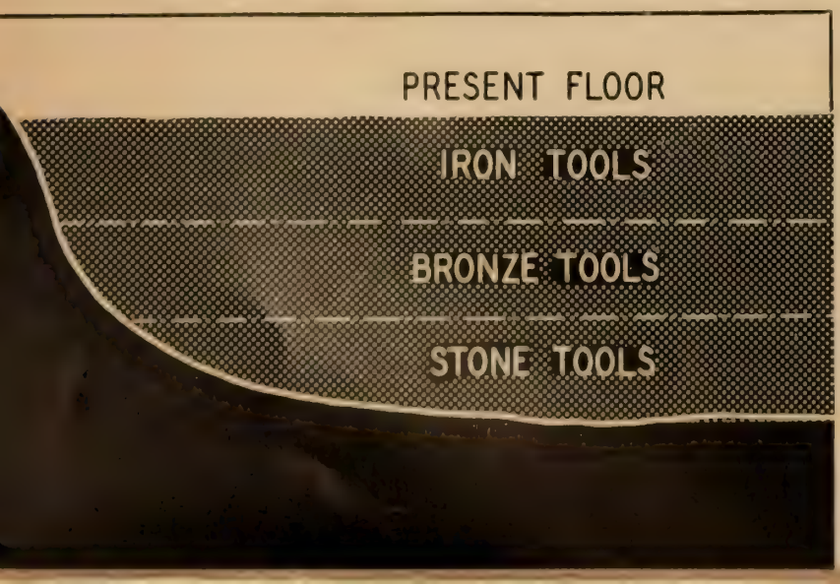
A. That wherever man disturbs the earth as laid down by nature, the scar remains forever, or at least until nature re-deposits that portion of the earth's surface. Nature alone can wipe the slate clean, ready to record the next series of human events.

B. That when a group of people lives for a time upon the same spot, a deposit of refuse or debris accumulates, mostly ashes and bones, among which are scattered lost and discarded useful objects. If this deposit has not been disturbed unduly, the oldest objects will lie near the bottom, the latest at the top. If the original community abandons the site, nature spreads a coat of soil over all, and when another community makes the same site its home, a second layer of telltale refuse is laid down upon this black-soil cover, and so on, ad infinitum.

C. If the same people live on the same spot for centuries, the tools and other products of their workmanship—artifacts in the archaeologist's language—will show significant changes from the bottom of the refuse upward. Especially is this evident among those which are ornamented. The idea that we alone of all peoples and ages progress, or change, is pure conceit. It is the universality of change in the ways of human living which makes archaeology possible; these changes register the march of time.

D. Human communities are never isolated for long. They watch their neighbors and imitate them. So the order of artifacts in one refuse heap can be checked by another in a near-by site.

↓ CROSS SECTION of a peat bed showing relative positions of objects belonging to the Iron, Bronze, and Stone Ages of Denmark. This principle of stratigraphy is the scientific basis of archaeology, first demonstrated by C. J. Thomsen in 1836



↓ SECTIONS IN A SHELL HEAP showing alternate layers of shell refuse and sand. The man-made shell layers indicate time sequence from below upward. (Pickwick Basin, Tennessee River, Ala., T.V.A. Project, excavated by Major W. S. Webb)



PHERS MAN'S PAST

When Archaeology Became a Science

ABOUT 1830, C. J. Thomsen, curator in a Danish museum, was busily receiving and cataloguing curious objects turned in by laborers digging peat for fuel. These objects were of iron, bronze, and stone. There were axes of these three substances, shields of bronze, and swords of both iron and bronze, not to mention hundreds of small objects. In course of time, Thomsen began to wonder which of these objects were invented first. He knew that peat deposits were built up slowly from the bottoms of ponds and swamps.

One day it occurred to him that the depths of the objects found in the peat should tell the story. After keeping such records for a few years he had the answer: iron above, bronze objects next below, stone near the bottom. He published a paper about as long as this article telling how he knew once and for all that the historic age of iron in Europe followed a prehistoric age of bronze, and that the latter was preceded by an age of stone. On that day scientific archaeology was born. Armed with such a logical tool of crystal truth, the archaeologist could revolutionize the knowledge of man and the way of thinking about him.



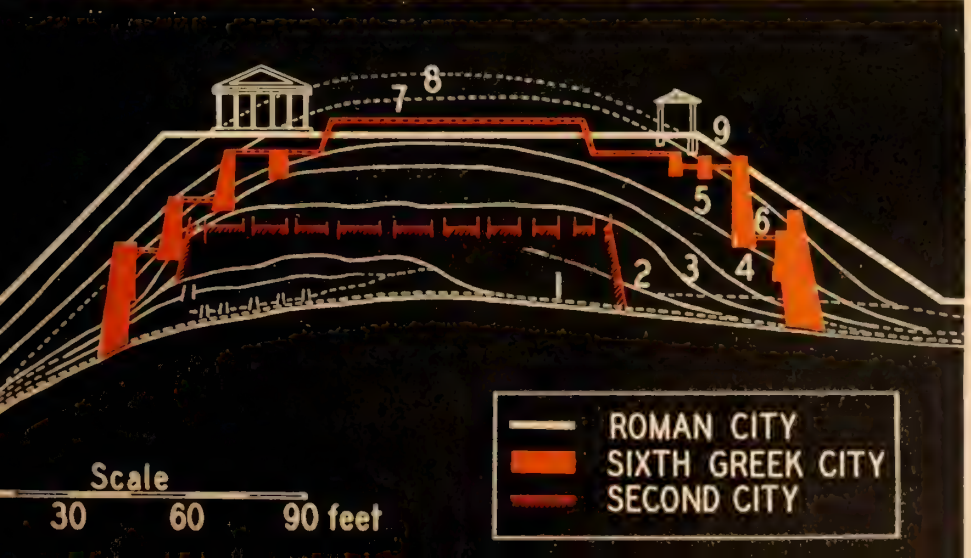
A. M. N. H. Photo

THE MOST PRIZED Bronze Age relics are large bronze trumpets in such perfect condition that folk music can be played upon them. This one is in the American Museum of Natural History

Pottery as a Time Marker

BEFORE 1912 many museums and amateur collectors had ransacked ruins of cliff-houses and prehistoric Pueblo Indians in New Mexico and Arizona, because they were rich in beautiful pottery. The burning question was, when were these ruined structures built? The professors who lectured on the archaeology of the Old World were enthused by Thomsen's discovery of time sequence—Stone Age, Bronze Age, Iron Age—but here in New Mexico were neither bronze nor iron—merely things made of wood, bone, shell, stone, and pottery. The most conspicuous was pottery. In the neighborhood of every ruin one could see bits of broken pottery upon the ground—potsherds of many colors, all mixed together in profusion. Most of these sherds were of

† THE NINE CITIES OF TROY excavated by Schlieman in 1870-1875, the first use of scientific methods in a large site. His Sixth City proved to be Homer's Troy, 1500 B. C. See, *Troy, a Study of Homeric Geography*, by Walter Leaf. Also, *The Discovery of Man*, by Stanley Casson





A. M. N. H. Photo

POTSHERDS from a room in the Pueblo Ruin at Aztec, New Mexico. Over 2700 sherds were found in the debris filling this one room. Sorting and assembling revealed eight nearly complete vessels and parts of 423 others from which restoration could be made. The ruin was excavated by Earl H. Morris for the American Museum of Natural History

thumbnail size and so numerous that a quart could be gathered in a few minutes.

There was a young curator in the American Museum who thought there should be some way to find the answer as to the age of the ruins. He consulted the then famous archaeologists of the country, but they said it could not be done, that they had tried and failed. Yet his faith was stubborn. He spent several seasons going about among these ruins. At first, he dug industriously within the walls of promising ruins, where he often found fine unbroken pots such as collectors prized, but the answer was not there. Then he noticed that immediately outside each ruin there was always a pile of ashes where the tidy prehistoric housekeepers dumped the sweepings from the family hearth, including other trash and especially potsherds.

This young curator was N. C. Nelson, now the Museum's distinguished senior archaeologist. We suspect that by this time the reader has guessed what Nelson had in mind; he believed that if he could find even a small section of an ash heap undisturbed by his pot hunting predecessors, the answer would be forthcoming. So Nelson went up and down the country picking up samples of the different kinds of sherds scattered round about a ruin, and doing a careful job of digging wherever he found the proper spot. In 1916 he published a short paper containing a time



A. M. N. H. Photo

➤ ABOUT 40 POTSHERDS from excavations at Sambayeque, Peru, appeared to belong to the same vessel. After a study of these and a number of broken vessels from the same site, a restoration was made in the American Museum of Natural History by Mr. Paul Richard, as shown at right.

The procedure was to place each sherd in its proper position according to shape and decoration. The sherds making contact at any point were fastened with "Duco." The empty spaces were filled in with plaster, which appears in the photograph as the lighter areas

sequence scheme for five types of pottery common to a large group of ruins in New Mexico. The consistent position of each pottery type in refuse heaps made the time sequence certain.

The effect of Nelson's paper can be easily imagined. It gave scientific archaeology in America a new birth. The younger archaeologists in the museums of the country were enthusiastic. What they saw was a new research tool, which if carefully used, could not fail. Ingenious guesses need not be regarded; let the potsherds speak for themselves. More and more field work would eventually solve the problem. Arizona and New Mexico soon became the main field for archaeological research; 20 years after Nelson's discovery of the basic scientific method an average of 40 archaeologists were making yearly excursions to that area.

In 1914 the American Museum initiated the use of a supplementary method for dating ruins. Professor A. E. Douglass, University of Arizona, was using growth rings of the Big Trees of California and other large trees to date changes in the annual rainfall. When rainfall is abundant trees grow thick rings, in dry years, thin rings. Many of the ruins in Arizona and New Mexico contain large ceiling and floor beams, sections from the trunks of trees. It occurred to the writer that if these could be dated by Douglass, the ruins could be dated. Douglass thought he could do it, if sample cuttings from logs in ruins could be sent to him. Earl H. Morris, then a staff archaeologist for the American Museum, was requested to collect the samples. The method worked from the start. Today the actual cutting years are known for beams in several hundred different ruins. The oldest so far is a small structure near Flagstaff, Arizona, dated 217 A.D.

The tree-ring method did not antiquate the value of potsherds, because the timbers in many ruins have decayed. Further, once tree-ring dates are found for a type of pottery, they can be transferred to the records secured by excavation. Finally, where tree-ring dates were to be had, it was observed that the durations for many pottery styles ranged from 75 to 150 years. This in turn gave a check upon time estimates in places where no wood survived. So it is easy to understand why archaeologists pay so much attention to potsherds. They aptly speak of them as "the fossils of culture."

In this instance the key to chronology was discovered to lie in color and surface finish, not in shape or design.



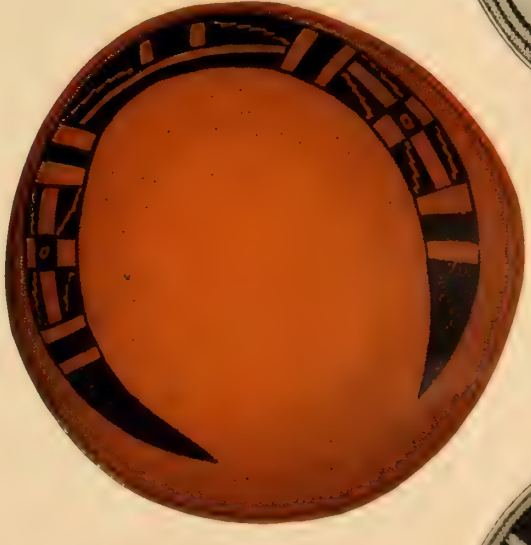
➤ Modern Ware. Black-on-pink and black-and-red-on-pink. 1680-1850



← Historic Two-color Glazed Ware. Brown or green on either gray, red, or yellow. 1450-1680



➤ Three-color Glazed and Painted Ware. Black-glaze-and-red-paint on either gray, yellow, pink, or red. (?)-1450



← Two-color Glazed Ware. Black or brown on either red, yellow, or gray. Date not known



➤ Two- and Three-color Painted Ware. Black on either white or red, and black-and-white on red. Date not known

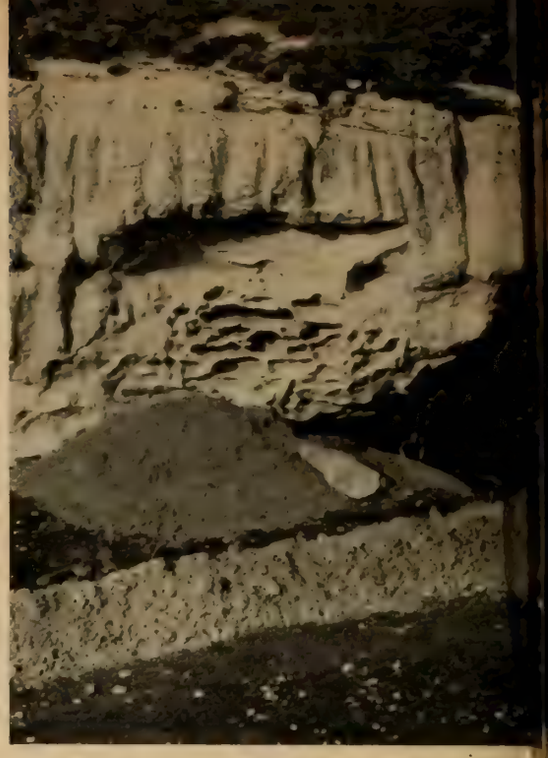
Drawings by Worthington H. Southwick

Caves and Shell Heaps

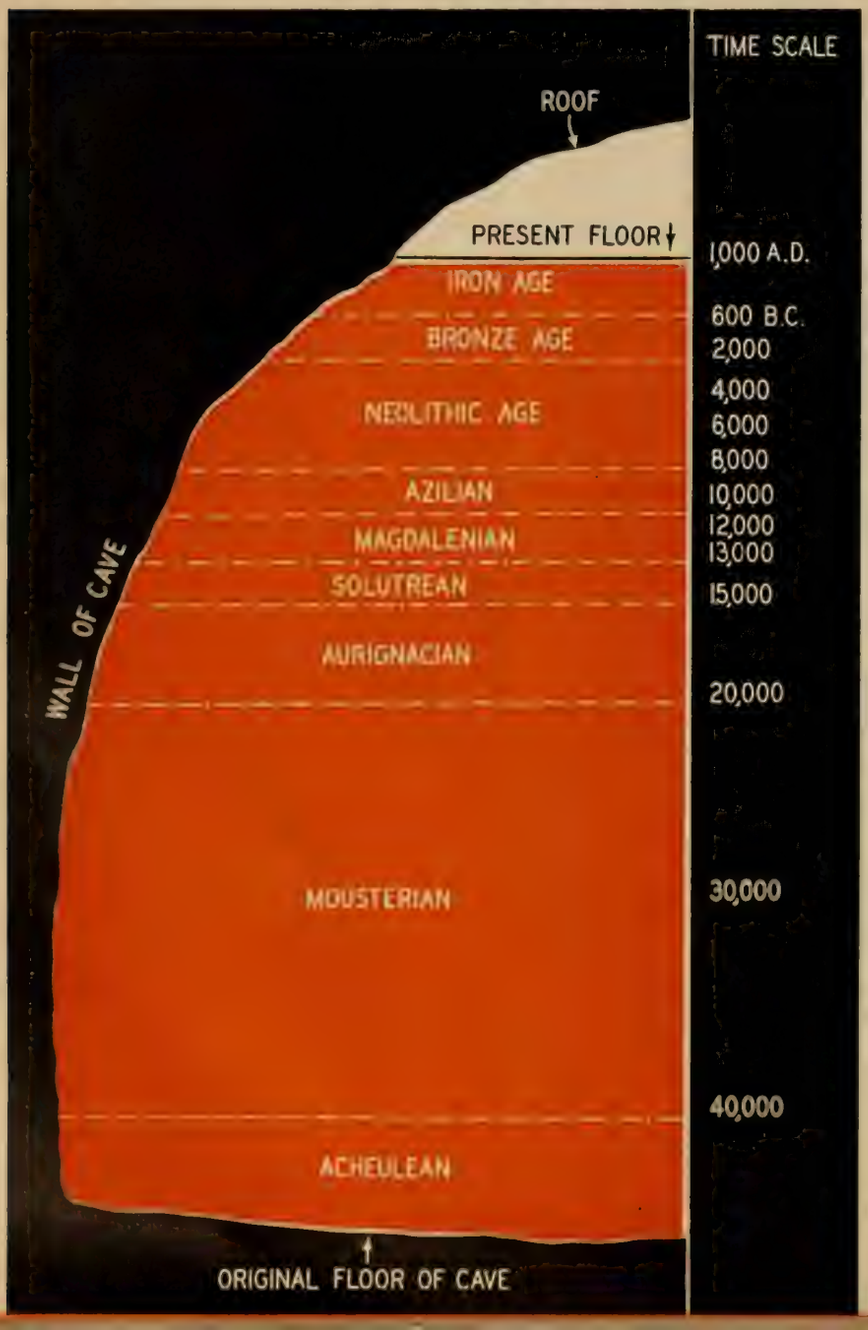
MOST people believe the first human beings were cave dwellers. This is more fanciful than true, but there is no denying that archaeology has learned a lot by the study of rock shelters and the entrances to caves, for the reason that such ready-made shelters were indestructible and so were occupied off and on by whatever people happened to be around. They were ideal defense positions against unfavorable weather as well as against animal and human enemies. Roomy rock and cave shelters were doubtless fought over time and again. Today archaeologists seek them because they contain precious beds of refuse, accumulated in orderly sequence and conserved, from which the past can be reconstructed.

Many of these shelters had such high ceilings that there was room to build up deep deposits of refuse. In Europe, for example, there are one or more cave shelters, the refuse in which reveals in time order all the main periods in the Old Stone Age, the New Stone Age, the Bronze Age, and the Iron Age. Rock and cave shelters are less conspicuous in America, but when found are highly prized by archaeologists. Several classic studies have been published by the American Museum, as for example Mammoth Cave, Kentucky, by Curator Nelson in 1915, and such caves as Cerro Sota and Fell's Cavern, Straits of Magellan, Chile, excavated in 1937 by Assistant Curator Junius Bird and his capable wife.

Yet if America does not lead the world in cave deposits, it does possess a grand series of shell heaps. These refuse heaps or kitchen middens line our coasts from Newfoundland southward, around the West Indies, down the east coast of South America to Cape Horn, thence up the Pacific side to Panama and on northward to the Arctic Circle and beyond. Shell heaps are not unknown inland. They are found, for example, along the Tennessee and the Ohio rivers, in fact, wherever edible fresh-water shellfish are abundant. Some shell heaps, or shell mounds, are of amazing size. The largest so far reported in the United States is about 30 feet high and covers 35 acres.



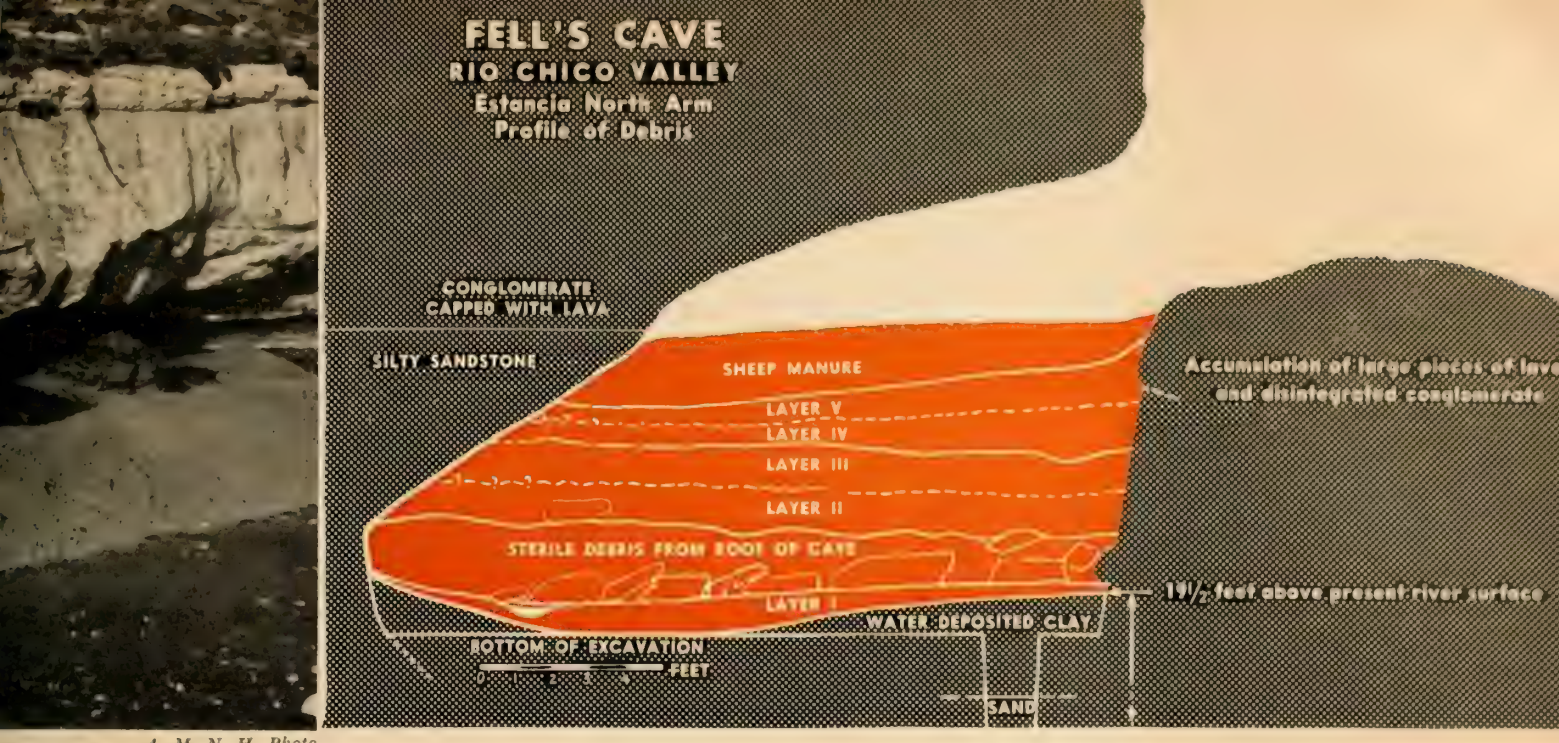
After Sir Arthur Keith; Courtesy William H. Wise and Co.



The reader need not be told how such shell mounds originate; they accumulate around the primitive cabins of shellfish eaters, together with bones, pottery, and discarded implements. As the level of refuse rises, new cabins will be built on the higher levels, and so on. Excavations in a large shell mound near Oak Hill, Florida, by Curator Nelson, showed that the Indians who started the mound did not make pottery, but eventually crude pottery does appear, which passes through several successive styles, culminating in ornate pottery.

It is expected that an archaeologist will save samples of the shells and bones for identification, to determine which of the animals are still living, which extinct. But for time sequences the chief dependence is upon the relative positions of the artifacts found in the refuse.

HAD EUROPEAN CAVE MAN lived in the same shelter for 50,000 years the debris would tell this story. Cultural changes are the archaeologist's key



A. M. N. H. Photo

✦ A CAVE IN SOUTHERN CHILE excavated by Junius and Margaret Bird, American Museum of Natural History. In the last layer in this cave were found artifacts and human bones associated with the bones of extinct animals

✦ FIVE PRE-COLUMBIAN PERIODS of occupation revealed in a Chilean cave. In Layer I were bones of the extinct wild horse and the sloth, the first sure evidence that man lived in South America before these animals disappeared

✦ NOT A CAVE but a cross section of an Ohio mound under excavation. Several burials have been exposed by clearing of the mound floor. They were covered with log tombs, the decay of which caused a settling in the original fill

Ohio State Museum photo





Chicago University Field Station

↑ WORKING OUT A SKELETON is an exacting test of skill. Tiny trowels, awls of small sizes, fine brushes, and a hand bellows are the important tools. Shellac or other fixing solutions should be at hand

Why Burials Are Important

ARCHAEOLOGISTS are fond of digging up the prehistoric dead. People who do not like archaeologists often show their contempt by calling them "grave robbers." Two important kinds of information come from graves. The skeletons tell us much about the people who lived at the time and place, and the man-made objects in the burial give information as to their mode of life. If time sequences are known for some of these objects, a given skeleton can be dated relatively. The better preserved skeletons can be distinguished as male and female; even the age at death can be determined within an average error of five years. The most thoroughly excavated prehistoric cemetery in America was connected with the Pecos ruins in New Mexico. More than 1800 skeletons were excavated. The ages at death were determined for a large number, the details of which cannot be given here, but we note that while a few of these Pecos Indians lived longer than 80 years, only 20 out of every 100 reached the age of 55 years. In a modern white community 50 out of every hundred live to be 55 years of age or more.

The successful removal of a skeleton often calls for unusual skill and an inordinate expenditure of time and patience. In damp ground bones may be so soft as to defy movement until hardened by drying or by special treatment with fixing solutions. An inexperienced digger may tear away a skeleton without being aware of its presence. Since the teeth are less likely to take on the color of the damp soil, a bungling amateur may report that he found no bones, merely a few teeth.

Burial is an old, old custom. The most important invention is fire, but archaeology shows that burial is almost as old and that with it came the custom of placing tools, weapons, and food in the grave. It is usual to infer from this that the belief in a life after death is still older.

Digging in a Village

AS AN example of the right way to work in a village site we have selected excavations by the Rochester Museum, Rochester, New York, directed by Dr. William A. Ritchie. Three field photographs are reproduced by permission of the author. The site of a former prehistoric village was located near the town of Brewerton at the eastern end of Oneida Lake, New York State. Refuse and burials resulting from this village covered a flat about three acres in extent. Eight trenches were used in exploratory excavations, and two "test blocks" were carefully worked out. Some 1700 recognizable stone artifacts were uncovered. There was some pottery but it was all on or near the surface, so it is clear that the first generations to occupy the site did not make pottery. Further, they lived there long enough to make some changes in the kinds of stone implements they used.

The scientific objective

The reader may wonder why all this trouble. Doctor Ritchie has specialized in the prehistoric cultures of New York State. In the United States archaeologists identify cultures and classify them systematically. Doctor Ritchie saw in certain sites from the same part of the State what he suspected were traits of a new culture. Objects picked up from the surface made him hopeful that this site at Brewerton might qualify as a type for such a new culture. His excavations indicated that he was on the right track. In the high-sounding language of the profession, he named it the Robinson site, or component, in the Brewerton Focus, Laurentian Aspect, Northeastern Phase, Woodland Pattern. If you had any doubts as to archaeology being a science, this should silence you. Should you wish to know what all this means, you must consult the technical books on the subject; it is as intelligible to an archaeologist as (robin) *Turdus*, syn. *Merula migratorius* is supposed to be to an ornithologist. Doctor Ritchie's achievement is about equivalent not merely to the discovery of a new species but a new genus as well.

Incidentally your curiosity may be appeased by outlining the standard scheme of archaeological classification, as:

Component (Site): Associated complexes of artifacts found in a village site or in a camp site.
Focus: A group of components or sites which approach identity in their dominant types of artifacts.
Aspect: A group of foci with important similarities.
Phase: A group of aspects with fundamental similarities.
Pattern: A few artifact types, widely distributed, common to a large number of components.



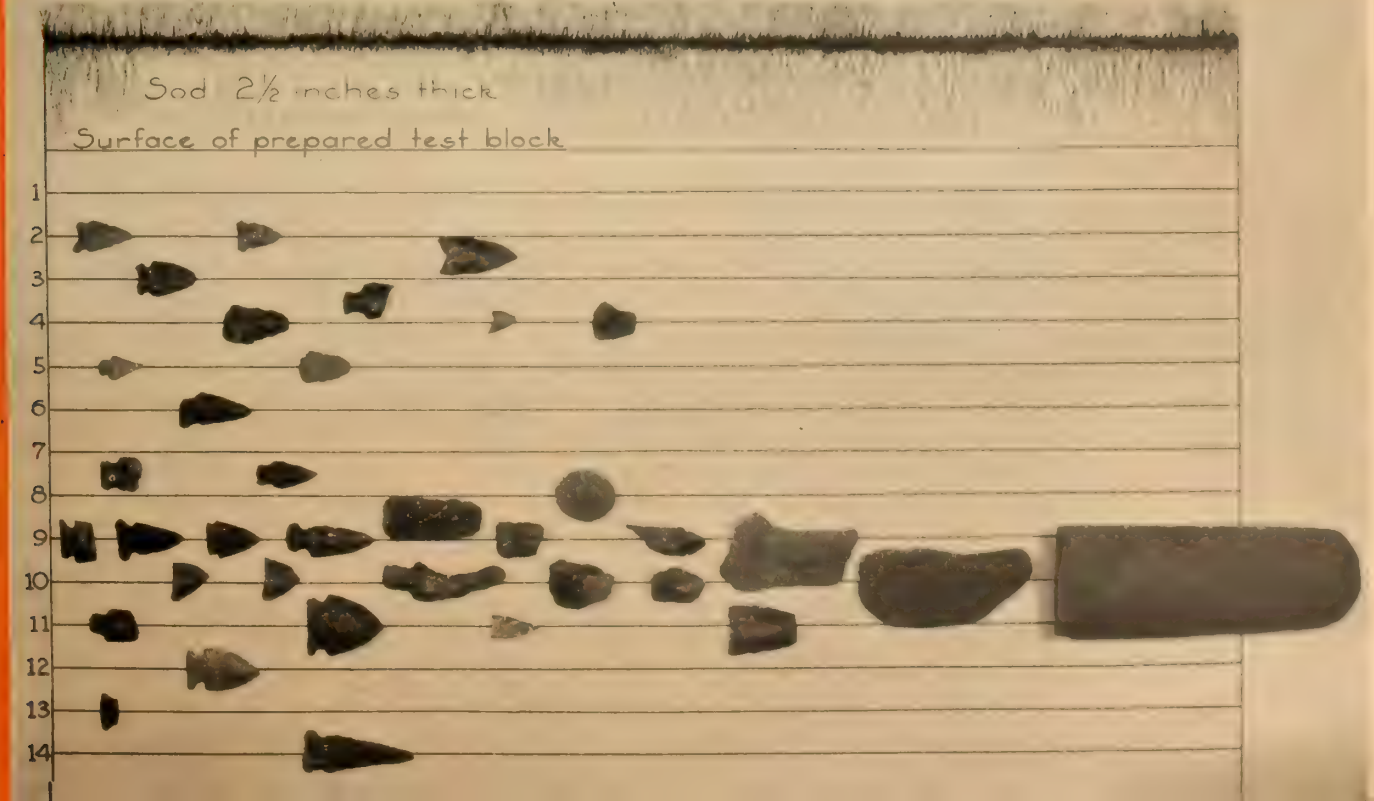
(*Above, right*) TEST BLOCK NO. 1 has been cut around for careful excavation. The sod has been removed and stakes set to guide the excavators



→ REMOVING THE EARTH in horizontal layers. Holes at the side mark storage pits beneath the village refuse

→ WHEN ALL ARTIFACTS were arranged in order, it was clear that most large projectile points lay below the ten-inch level, most small points above. Similar differences for other artifacts were noted, showing the general time sequence in culture during the period of occupation. Pottery occurred on the surface only

Photographs by courtesy of the Rochester Museum





Chicago University Field Station

Post Holes

↑ POST HOLES reveal the layout of houses, defense palisades, scaffolds, etc. To overlook them when digging is inexcusable. With practice they are easily dissected out. In this instance there seem to have been two successive houses on the same site

↓ BY SLICING down below the original house floor the depth and direction of the post holes can be shown. The parallel lines have been marked according to the intersecting lines on a plan of the site, for ease in reading the photograph

Major W. S. Webb



Stakes

→ The positions of all objects uncovered are plotted on the base map in relation to stakes previously driven into the ground. Exploration of a burial ground begins with the digging of trial trenches, usually at right angles, as at right. Test blocks are then selected for thorough excavation. In this instance the burials were in a part of the accumulated village refuse, probably because graves were easily dug therein



→ The trench at this stage shows burials partly worked out. A careful record will be kept as the material is removed and studied. This is the same site as above on Seven Mile Island, Tennessee River, worked under the T. V. A. Archaeological Project by Major W. S. Webb, Director, 1936-38



→ In the refuse of this village site there were many pits. The archaeologists cut around these so as to leave the original blocks for dissection and study. Some pits were lined with clay but were found filled with loam containing a few artifacts of stone, copper, and galena. This is at Pickwick Basin, Tennessee; Major W. S. Webb, Director



→ Village sites are explored by removing the debris down to the original hard surface of the ground. The material is carefully peeled off in thin horizontal layers. For the most part small trowels are used. (Chicago University Field Station)



1 Archaeologists must be patient, industrious, and resourceful. Major W. S. Webb's trenches and camp were flooded one night. Records were damaged and equipment lost, causing delay and extra work. (Tennessee River T. V. A. Project)

2 Mrs. Junius Bird on shift at Palli Aike cave in Chile. Dry caves preserve perishable materials, but the fine powdered dust rises with every step, and masks must be worn. As the debris is removed it should be screened to save tiny objects

3 Mr. and Mrs. Bird found peace-time gasoline shortages in southern Chile an aggravation. The expedition Ford responded to both wind and man power, but ultimately a yoke of plodding, time-consuming oxen was found the best solution



1

→ Archaeology can recover lost history. Jamestown, Virginia, was settled in 1607, but the town was destroyed in 1698. Recent excavations by an archaeologist have given new information. Foundations of forgotten houses with cellars filled with debris were uncovered. The streets of the old town were traced. (Archaeologist, Jean C. Harrington, National Park Service)



→ Thousands of potsherds and objects of glass, iron, and stone were uncovered. These were cleaned and repaired in the laboratory at Jamestown. Most of the objects were brought from England between 1607 and 1698, so this dates them, even though their history in England has been lost





A. M. N. H. Photo

2



A. M. N. H. Photo

3



TOOLS FOR FARMING AND BUILDING



← TYPICAL OBJECTS from excavations at the site of Jamestown. The number and variety of glass wine and rum bottles is impressive. Household pottery is abundant. Clay tobacco pipes of many styles were found. Some fine decorated tiles probably came from Holland

EQUALLY INTERESTING are the objects of iron and steel (*at bottom*). The National Park Service has used archaeological methods in St. Augustine, Florida, Roanoke Island, North Carolina, and many other historic sites. In Canada archaeologists have found the correct locations for a number of old fur trading posts. Recently archaeologists from Harvard began excavations in Plymouth, Massachusetts. Obviously the future will see our own history greatly enriched by archaeological research

Step By Step



1 PLANNING THE PROJECT: the Director of Excavations and graduate students in conference, Chicago University Field Station. After a careful examination of a site a detailed plan for its excavation must be made. A temporary building may be erected as a field laboratory, where drawings can be made, notes and photographs filed, conferences held, etc.



Major W. S. Webb

2 A VIEW OF THE SITE: two mounds before excavation. If a mound has not been cultivated or otherwise greatly disturbed, it will be covered by trees and underbrush. This coverage must be cleared away before excavations begin

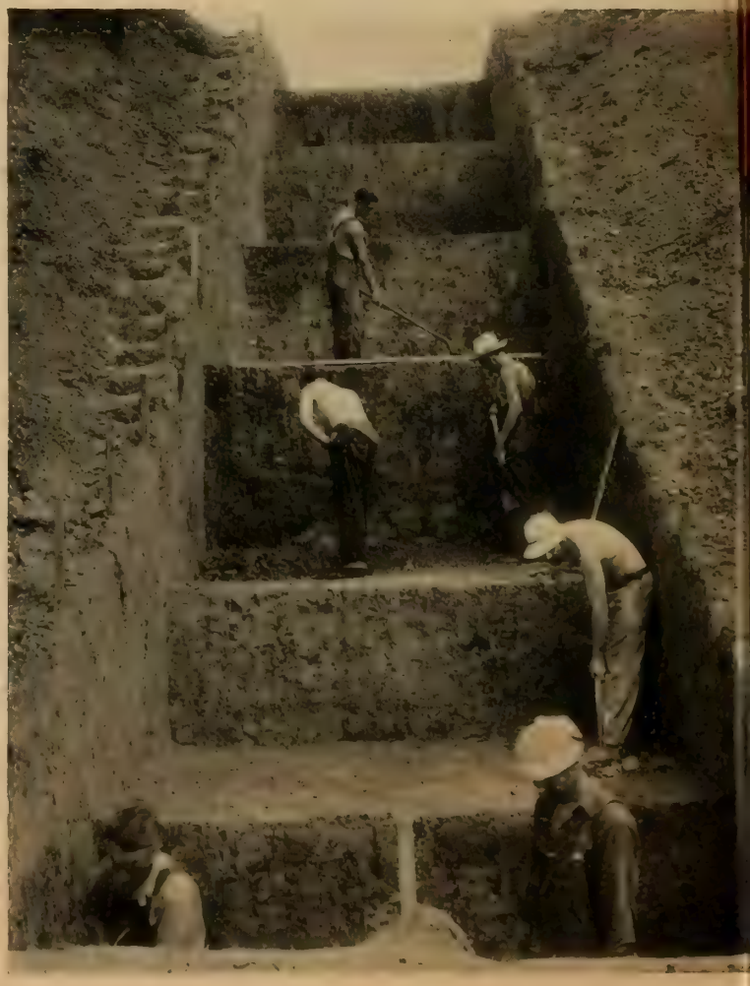
5 → EXCAVATION UNDER WAY: a view showing a cross section of a mound. The blocks of earth contain burials to be worked out later. The base of the mound is shown in the foreground

Major W. S. Webb



6 → AN ALTERNATIVE METHOD: step-trenching a mound instead of beginning at the base. The planes defined in the survey plan must be followed to record objects found. Note the stakes

Chicago University photo





Chicago University Field Station



Major W. S. Webb

3 THE SURVEY. Before digging, a survey must be made to establish the horizontal and vertical planes needed to record the positions of all objects found. Meanwhile, clearing of the surface may be under way

4 THE BASE PLAN of the mound is divided into squares marked by vertical stakes. These are driven down as excavation proceeds. Usually each stake is numbered to assist in recording the objects found

THE MOUND CLEARED AWAY. The original floor of the mound usually approximates the basal horizontal plane. The stakes, now much lower level, are still in their original relative positions

Chicago University Field Station photos



CLEANING THE SPECIMENS: students of archaeology washing potsherds before assembling them in their original order as avated for determining time sequences





Trailside Museum photo

← MASTER SCOTT finds door to a hidden cave

What to Do When You Discover A New Site

IN SOME of the pictures you may note post holes which have been cleaned out to show the positions and sizes of the posts originally standing there. These holes tell us something about the buildings once occupying the site. Even a piece of matting may leave an imprint in the earth which can be worked out to reveal the weaving technique. H. C. Shetrone, Ohio's leading mound expert, is able to trace out the individual loads of earth dumped down by the carriers in building the mound, even finding the imprint of a basket which one of them failed to empty. Not all archaeologists are so skilful, but many of them are. It is clear that an ignorant careless digger would not only fail to see these important things but would destroy all traces of them.

The archaeologist is pleased when so many people take an interest in his subject, but he cannot be happy over their enthusiasm to dig things out, because he knows too well how blind they will be to what should be recorded. We hope the reader has acquired some idea of the responsibility he assumes when he digs into a rock shelter or a prehistoric grave.

We have but space enough to mention how a boy, Robert D. Scott of Fort Montgomery, New York, noticed a small hole in the face of a cliff. Entering, he found himself in a small cave, upon the floor of which he saw bits of pottery. He reported his find to the archaeologist in the Trailside Museum at Bear Mountain. Young Scott was rewarded by assisting in the excavations, was heralded in the press as "the luckiest boy in the United States," and duly praised for his good sense in not trying to dig out the "relics" secretly. The *New York Times* made his achievement the subject of an editorial (May 11, 1941), reprinted below:

Lucky Boy

"Robert D. Scott is 13 years old and in the seventh grade of the Fort Montgomery grammar school. At this moment he is the luckiest boy in the United States, having just done what every normal boy in the United States wants to do. He found a hidden cave with a treasure inside. Nobody had been in that cave for unknown hundreds of years. Robert wormed his way through a boy-sized hole, which had been left when an ancient earthquake closed the entrance. Inside he found Indian pottery, arrowheads, medallions of slate once worn around Indian necks, and an old pipe of red clay.

"It seems a shame to reveal the location of Robert's cave, but its picture has already been in the papers. It is not far from the Bear Mountain bridge. Archaeologist James D. Burggraf of the Trailside Museum believes that it was used by Algonquin fishermen before the time of Columbus. To an archaeologist it is tremendously exciting to get evidence that the Algonquins were in this part of the Hudson Valley before the Iroquois pushed in and established a kind of corridor between the two great sections of the Algonquin race. The Iroquois, in short, weren't old settlers at all. They happened along after the pioneering was finished.

"Robert would be richer if he had found a couple of kegs of pieces of eight. But Indians are more fun. They teach a useful lesson, too. Robert can tell his elders with some assurance that ten or twenty years of big noises in Europe or China aren't all there is in the history of the human race. If we have to go back to living in caves it won't be the first time. We can stand it."

From the New York Times

Additional Information on Archaeological Methods

THE following publications have been selected to give more detailed information as to the techniques of archaeological excavation and the interpretation of the data. Some of them contain instructive photographic reproductions of trench-sections, artifacts, and diagrams of stratigraphy.

Antiquity and Migrations of the Early Inhabitants of Patagonia. By Junius Bird. The Geographical Review, Vol. 28, No. 2. 1938

The Discovery of Man. By Stanley Casson. New York. 1939

Man Makes Himself. By Gordon V. Childe. London. 1936

Rediscovering Illinois. By Fay Cooper Cole and Thorne Duell. Chicago. 1937

The Su Site, (New Mexico). By Paul S. Martin. Field Museum of Natural History, Chicago. Vol. 32, No. 2. 1943

Digging in the Southwest. By Ann Axtell Morris. New York. 1933

Digging in Yucatan. By Ann Axtell Morris. New York. 1931

The Aztec Ruin, (New Mexico). By Earl H. Morris. Anthropological Papers, American Museum of Natural History. New York. Vol. 26, Part 1

Chronology of the Tano Ruins, New Mexico. By N. C. Nelson. American Anthropologist N. S. Vol. 18, 1916, pp. 159-180

Contributions to the Archaeology of Mammoth Cave and Vicinity, Kentucky. By N. C. Nelson. Anthropological Papers, American Museum of Natural History, New York. Vol. 22, Part 1. 1917

Chronology in Florida. By N. C. Nelson. Anthropological Papers, American Museum of Natural History, New York. Vol. 22, Part 2. 1918

Two Prehistoric Village Sites at Brewerton, New York. By William A. Ritchie. Research Records of the Rochester Museum of Arts and Sciences, No. 5, Rochester, N. Y. 1940

The Mound Builders. By Henry Clyde Shetrone. New York. 1930

An Archaeological Survey of the Norris Basin in Eastern Tennessee. By William S. Webb. Bureau of American Ethnology, Bulletin No. 118. Washington, D. C. 1938

An Archaeological Survey of Pickwick Basin in the Adjacent Portions of the States of Alabama, Mississippi and Tennessee. By William S. Webb and David L. DeJarnette. Bureau of American Ethnology, Bulletin No. 129. Washington, D. C. 1942

OTHER PUBLICATIONS on Archaeology

Order any of these items through Man and Nature Publications, the American Museum of Natural History, Central Park West at 79th St., New York City, N. Y. They are all published by the Museum

ANCIENT CIVILIZATIONS OF MEXICO AND CENTRAL AMERICA. By Herbert J. Spinden, Ph.D. *Third and revised edition, 1928. 270 pages, 48 plates, 86 text figures, map and diagram. Handbook No. 3. Cloth, $1.00; postage, 7 cents.*

This book is intended as a general commentary and explanation of the more important phases of the ancient life and history of the Indians of Mexico and Central America, popularly considered as Aztecs but actually including a number of distinct though related races, notably the Maya.

OLD CIVILIZATIONS OF INCA LAND. By Charles W. Mead. *Second edition, 1932. 141 pages, many illustrations and a map. Handbook No. 11. Cloth, $1.00; postage, 7 cents.*

A book describing the arts and industries of the highly civilized Incas of South America, their marvelous textiles and extraordinary skill in stone work.

MASTERPIECES OF PRIMITIVE SCULPTURE. By George C. Vaillant, Ph.D. *1939. 11 pages, 23 illustrations. Science Guide No. 99. Price, 25 cents; postage, 3 cents.*

An excellent presentation of the sculpture of the primitive peoples of the world, profusely illustrated by striking examples from the collections of the American Museum. This leaflet is adapted for use by students of archaeology and artists interested in primitive sculpture.

THE HALL OF THE AGE OF MAN. By Henry Fairfield Osborn, Ph.D. *Seventh edition revised to 1938 by William K. Gregory and George Pinkley. 54 pages, numerous illustrations. Science Guide No. 52. Price, 50 cents; postage, 3 cents.*

This describes the exhibits in the American Museum illustrating what is known of the origin, relationships, and early history of man as deduced from his remains and implements. It also shows the paintings by Charles R. Knight depicting the animals by which man was surrounded in the early stages of his existence.

POTTERY OF THE SOUTHWESTERN INDIANS. By Pliny Earle Goddard, Ph.D., *1931. 30 pages, 22 illustrations. Science Guide No. 73. Price, 30 cents; postage, 3 cents.*

A description of the methods of making pottery, as well as the sequence of types.

SOUTH AFRICAN ROCK PICTURES. By N. C. Nelson. *1938. 12 pages, 12 illustrations. Science Guide No. 93. Price, 30 cents; postage, 3 cents.*

A description and discussion of the primitive pictorial art exemplified by the rock pictures recently discovered in South Africa, including facsimile illustrations of various typical examples.

PERUVIAN ART. By Charles W. Mead. *Fifth edition, 1929. 24 pages, 9 full-page plates. Science Guide No. 46. Price, 10 cents; postage, 3 cents.*

Showing how the strange designs of the ancient Peruvians on textiles and pottery are really representations of birds, beasts, and fishes. A help for students of design.

ARTISTS AND CRAFTSMEN IN ANCIENT CENTRAL AMERICA. By George C. Vaillant, Ph.D. *1935. 102 pages, numerous illustrations. Science Guide No. 88. Price, 70 cents; postage, 3 cents.*

This provides examples of the extraordinary range of Central American art and gives a general picture of Pre-Columbian sculpture and architecture.

THE HISTORY OF THE VALLEY OF MEXICO. By George C. Vaillant, Ph.D. *1940. Science Guide No. 103. Price, 10 cents; postage, 3 cents.*

A folded chart, serving as a supplement to *Artists and Craftsmen in Ancient Central America* (above) : a graphic presentation showing the successive stages of Mexican art from 100 B.C. to 700 A.D.

Insect Control IN THE *Victory Garden*

By C. H. CURRAN

ASSOCIATE CURATOR OF INSECTS AND SPIDERS



SCIENCE GUIDE No. 117 — THE AMERICAN MUSEUM OF NATURAL HISTORY

ACKNOWLEDGMENT

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Insect Control

IN THE

Victory Garden

By

C. H. CURRAN, D.Sc., B.S. Agric.

SCIENCE GUIDE No. 117

THE AMERICAN MUSEUM OF NATURAL HISTORY

1943

The Healthy Garden

The victory gardener, whether amateur or seasoned veteran, is certain to be worried by insect pests. Some of these are capable of causing serious losses, but it is comforting to know that, with regular examination of plants and the use of simple control methods, the ordinary small garden will come through the season with little or no loss. The victory gardener has a big advantage over the commercial grower because he can keep a keen watch on almost every individual plant. Hand picking of most pests is all that will be necessary. There are only a few kinds of garden insects that will require chemical treatment, and this does not call for extensive equipment or a large variety of insecticides.

Before discussing the various insects and insecticides, we may consider the value of certain cultural practices in controlling some kinds of insects, and the effect of environment on the garden and on the insect problem in general. The position of the garden in relation to other gardens is important, because if gardens are contiguous and the same crops are grown in all, the danger of insect damage is much greater. At the same time, control measures may be more economically carried out if a number of gardeners cooperate in buying equipment and in mixing insecticides for all the gardens at one time.

It is generally agreed that clean culture reduces insect damage. However, the small gardener cannot always practice clean culture. Adjacent yards may contain numerous weeds and debris, and insects may flourish in these. To cut the weeds after they have grown does not help the isolated gardener; it makes matters worse, because some kinds of insects infesting the weeds will migrate to garden plants.

Gardens adjacent to waste land and weed patches are very frequently subject to damage by cutworms and other migratory caterpillars. In order to guard against these it is frequently advisable to carry out cutworm control before setting out garden plants.

The general cleanup of adjacent waste land should occur in the fall in order to remove overwintering protection for insects, or in the very early spring. Late spring or summer cleanup will cause tarnished plant bugs and other pests to move to the garden. It is often better to leave lush growing weed patches alone at this time, because the pests will find plenty of food there.

No attempt has been made to include all the insects found in the vegetable garden, and some crops that are not suitable to the victory garden are not mentioned. The more common pests are discussed and control measures given for these. Other insects with similar habits may be controlled by the same treatment.

Insecticides

Two types of insecticides are used in insect control—stomach poisons for chewing insects and contact poisons for sucking insects.

Stomach Poisons

Stomach poisons are used in the control of chewing insects. They may be applied either as a spray or a dust, but the average victory gardener will find spraying more satisfactory and less expensive.

Arsenate of Lead

This is the best known of the arsenical poisons. It is a white powder and is used at the rate of 1 to 2 pounds to 50 gallons of water. It is a rather slow killer but is safe to use because it does not burn the foliage. To prepare dust, mix 1 pound of powder with 6 to 8 pounds of hydrated lime or 9 pounds of dusting sulphur.

Arsenate of Lime

This is a fine white powder with fast killing properties but apt to burn the foliage. It is used at the rate of ¾ pound to 50 gallons of water, 2 pounds of hydrated lime being added to prevent burning. It does not adhere as well as arsenate of lead but is the cheapest of the arsenicals. For dusting, mix 1 pound with 10 pounds of hydrated lime.

Paris Green

This is the oldest of the arsenical insecticides and is still used for the potato beetle and in poison baits. Other arsenicals are as good for potato beetles. With half a pound of Paris green in 50 gallons of water, add 2 or 3 pounds of hydrated lime to prevent burning. For dusting, mix one pound of Paris green with 20 pounds of hydrated lime.

Magnesium Arsenate

This is a white powder, chiefly used in the control of Mexican bean beetles. It is mixed at the rate of 1 pound to 50 gallons of water. When used as a dust, 1 pound of the powder is mixed with 10 pounds of hydrated lime.

Sodium Fluosilicate

Normally a white powder, this chemical contains a green dye when used for household insects. It is used in the control of the Mexican bean beetle. Mix about 1½ pounds per 50 gallons of water. As a dust, dilute at the rate of 1 pound to 8 or 9 pounds of hydrated lime.

Contact Insecticides

These are used in the control of sucking insects and kill by direct contact.

Nicotine Sulphate

This is the most commonly used contact insecticide and it is the one that will be chiefly used during the war. The standard for nicotine sulphate is 40% nicotine, and dilutions are based on this content. Six ounces make 50 gallons of spray. The addition of 2 pounds of soap to this amount increases the efficiency of the spray. For use as a dust, mix 5 pounds with 100 pounds of hydrated lime.

Pyrethrum and Rotenone

Rotenone is not available at the present time, but a limited amount of pyrethrum is available in packages of 1 pound or less. This powder is applied as a dust. It is used chiefly for the control of the cabbage butterfly and the Mexican bean beetle and must be applied every 10 days to 2 weeks to be effective.

Soap

Soap has been pretty generally replaced as an insecticide by the other contact sprays, but it can be used in the control of aphids. Three pounds of laundry soap will make 5 gallons of spray. The soap is cut into thin strips and dissolved in hot water. The solution is then diluted to the final amount.

The chief use of soap is as a spreader in sprays, and it is then used at the rate of 2 pounds dissolved in a small amount of water to 50 gallons of spray.

Nicotine Spray

The smoker of cigars and cigarettes may make a spray that will prove satisfactory in the small garden. Cigar and cigarette butts may be saved, thrown into a bucket of water, and allowed to soak. In order to determine whether the liquid is strong enough, it can be tested on aphids, of which there are certain to be many in or near the garden. It is advisable to remove the charred ends of the cigarettes, otherwise the liquid will be very dark and the odor unpleasant. The liquid may be strained through a cloth in order to remove particles that would clog the sprayer.

Tobacco Dust

This usually comes diluted and ready to apply. It is useful for aphids and flea beetles and also serves to some extent as a soil insecticide.

Bordeaux Mixture

This is a combination of bluestone (copper sulphate) and lime. It is prepared by dissolving 3 pounds of bluestone in water, mixing 3 pounds of hydrated lime separately in water, and combining the two. This is diluted to 50 gallons. When using the commercial dust to make a spray, follow the table on page 6. If Bordeaux powder is to be made at home, finely

AMOUNTS

Amounts of concentrated insecticides to produce convenient amounts of spray or dust

SPRAYS	For a small garden, mix any of these with 1 gal. of water	For a medium size garden, mix any of these with 6 gals. of water	For a large garden, mix any of these with 25 gals. of water
Arsenate of lead	3 teasp.	2 oz.	8 oz.
Arsenate of lime	2½ teasp.	1 oz.	6 oz.
Hydrated lime	2½ teasp.	1 oz.	6 oz.
Paris green	1½ teasp.	¾ oz.	4 oz.
Hydrated lime	1 oz.	4 oz.	1 lb.
Nicotine sulphate (40% Nicotine)	1½ teasp.	8 teasp.	4 oz.
Soap	1 oz.	4 oz.	1 lb.
Bordeaux mixture powder	2¾ oz.	1 lb.	4 lbs.

DUSTS	For a small garden, mix any of these with 5 lbs. of hydrated lime	For a medium size garden, mix any of these with 10 lbs. of hydrated lime	For a large garden, mix any of these with 50 lbs. of hydrated lime
Arsenate of lead	10 oz.	1¼ lbs.	6¼ lbs.
Arsenate of lime	7¼ oz.	14½ oz.	4½ lbs.
Paris green	5 oz.	10 oz.	3⅛ lbs.
Nicotine dust (For a 3% mixture)	6 oz.	12 ozs.	3¾ lbs.
Nicotine dust (For a 5% mixture)	9½ oz.	1¼ lbs.	6½ lbs.

ground bluestone must be used. The dust contains 1 part of bluestone to 8 to 10 parts of hydrated lime.

Corrosive Sublimate

This is a special insecticide used in the control of root maggots. It is a heavy white powder, which is dissolved in water at the rate of 1 ounce to 12 gallons. It is extremely poisonous and must be handled with care, but, as used in the vegetable garden, it is perfectly safe.

The solution destroys metal containers, so the powder must be dissolved in a wooden, glass, or earthenware container. A stock solution may be made by dissolving an ounce of powder in warm water and diluting to 1 gallon. This stock may be stored in quart jars, 1 quart being added to 3 or 4 gallons of water when ready to apply.

Danger of Arsenical Poisoning

Many people fear being poisoned as a result of eating vegetables that have been sprayed by poisonous substances, particularly arsenicals. Although arsenicals have been used for spraying for about 75 years, it was only after the last war that attention was focused on arsenical poisoning. This came about through the British Government's limiting the amount of lead arsenate residue to be allowed on imported apples. The British were not so much concerned about the arsenic as about the lead, which remains in the body and may cause lead poisoning.

It is perfectly safe to use arsenicals on all vegetables, and their use is recommended by the Canadian Government. If applied according to directions and if the vegetables are well washed before cooking, there is absolutely no danger of poisoning. As an added precaution, do not use the cooking water from plants recently sprayed with arsenicals for making soup. To escape any possible danger of lead poisoning, use calcium arsenate.

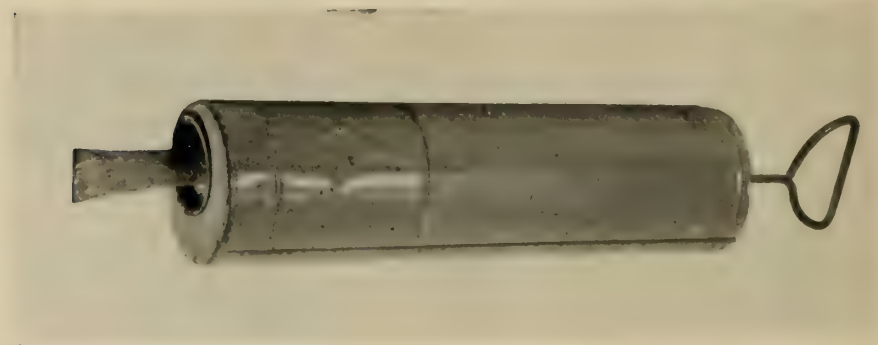


Small type hand sprayer



Above, 5-gallon knapsack sprayer

Left, stirrup pump bucket sprayer



Small type of hand duster

Applying the Insecticides

Spraying

To protect plants properly, spraying must be thorough, and the beginner may have difficulty in determining this. If spray drops from about one-fourth of the leaves, and almost all show signs of spray dots above, and it is felt that most of the leaves have been sprayed below, then the job is satisfactory. The novice is likely to use more spray than necessary, but it is better to use too much than not enough. Only experience will provide a proper balance. When plants are small, the garden may need only a quart of spray, but when they become large several gallons may be required.

Some insects feed on the under side of the leaves, and some on the upper side, while others may chew the whole leaf. A good policy in spraying is to spray the under sides of the leaves to such an extent that the drifting spray will be sufficiently heavy to allow about 50% of the upper surface to glisten. Begin on one side of the row at one end and work backward until that side is finished. Repeat on the other side, also taking in that side of the next row. When treating the lower leaves of beans, cabbages, and other low-growing plants, keep the spray gun well away from the plants and as close to the ground as possible. If you have a sprayer with an up-turned nozzle the task will be greatly simplified.

In using contact sprays, the task is often simplified. Some of the insects to be killed feed on fully exposed surfaces of the plants, so it is possible to hit them with a direct spray from several angles. However, some insects curl the leaves of the plants, and unless the culprit is actually hit the spraying will be ineffective. Contact sprays must be much more thoroughly applied than stomach poisons if satisfactory results are to be obtained.

Spraying Equipment

The spraying equipment will depend upon the size of the garden or gardens it is to cover. It must be remembered that only certain of the vegetables will need spraying. In the average garden of less than 10,000 square feet no special spraying equipment is necessary, providing the gardener has a good spray gun. If the garden is not more than 2,000 or 3,000 square feet the ordinary, small household "flit" gun will prove ample. In larger gardens a large "flit"-type gun will do the work. In gardens of over 10,000 square feet one of the small knapsack spraying machines of about 5 gallons capacity is advisable.

Time to Spray

It is not necessary in a small garden to apply preventive sprays where daily inspections will reveal insect damage as soon as it starts. However, the week-end gardener may find it advisable to, especially if there are extensive gardens close by from which pests might migrate. Cabbages, cauliflowers, and tomatoes may be given preventive sprays to advantage, and it is often advisable to spray the lower surfaces of the leaves of beans to protect the plants against the attack of the Mexican bean beetle.

Spraying may be done at any time during the day, but the spray should not be applied while the leaves are wet as the result of rain or heavy dew. The spray must dry on the plants and once it has dried it usually adheres for several weeks. If washed off by heavy rains, it must be renewed if there is further evidence of insect damage. The new growth, after spraying, is not protected, and this may necessitate further applications. The need for a second or third application can only be determined by the abundance of the pest and a knowledge of its habits.

Never spray more often than necessary, and spray only if it is obvious that control cannot be obtained by hand picking. Remember that insecticides are limited in quantity during the war and that the use of any alternative control measure is a direct contribution to our war effort.

When properly timed, one application should prove sufficient. A second should not be made unless absolutely necessary. Spray only when you feel sure that the increase in yield will much more than pay for the cost of materials. All of the insecticides recommended at the present time can be kept for years without deterioration. Some of the ingredients in insecticides are essential to war industries but they have been made available in order that you may aid in maintaining our food production.

Combination Sprays

It is possible to use all three types of spray—contact, stomach poisons, and Bordeaux mixture—in a single application, and this is often done, though it is wasteful of materials. The best practice is to apply arsenicals and Bordeaux together, since these two give control of all biting insects, as well as of fungus diseases. Contact sprays should be applied separately, and only where needed.

If you desire 6 gallons of spray, use 6 gallons of water but mix in the full amount of the arsenical and Bordeaux just as if you were making 6 gallons of each. For example: 1 oz. arsenate of lime, 1 lb. Bordeaux mixture, 6 gals. water. If the regular amount of water for each insecticide separately were used, the spray would be so dilute as to be ineffective.

Spray Injury

Spray injury results from applying a mixture too strong for tender foliage.

It is usually first apparent on the tips and edges of leaves, where drops of spray have collected and dried. The edges of the leaves dry out, wilt, and turn brown. If the injury is severe, the plant may become defoliated. Damage is most likely to occur when arsenicals or oils are used. Arsenical injury may be prevented by the addition of hydrated lime. The amounts specified in the table are more than adequate.

Dusting

Many insecticides are now applied in the form of a dust. The dusts consist of the various kinds of insecticides diluted with a number of different materials, most of which have some insecticidal value in their own right. The dusts must be applied with a dusting machine, and while in peace-time a number of types are available, few are apt to be procurable during the war. However, some victory gardeners may already own dusters and may prefer dusting to spraying.

Dusting has some advantages, especially in the commercial growing of crops, but the only advantage it offers the small gardener is that it is cleaner. In the long run it is much more expensive, since the materials cost more and more applications are needed. The recognized disadvantages of dusting are that the distribution of materials on the plants is uneven and the dusts wash off more readily than sprays. These disadvantages are more than offset when treatment is on a large scale, particularly where airplane dusting is possible.

Dust must be applied when there is little or no wind. When arsenicals are used alone, the dusting should be done in the morning or evening when there is dew on the plants. Dusting with contact insecticides gives best results during the hottest part of the day, and only when the temperature is above 70° F. However, it may be economical to apply two or more dusts in the same operation.

In general, the same rules must be followed as for spraying, and every effort must be made to get the dust on the under side of the leaves. This is sometimes difficult with low-growing plants.

Suds, Dishwater, and Soap

The use of suds and dishwater for the control of some garden insects, particularly aphids, is often recommended. These materials are of little, if any, value as insecticides. A soap solution, to have satisfactory insecticidal properties, must contain at least 4 pounds of strong soap for each 10 gallons of water, and even at this concentration it is inferior to other

contact sprays or dusts. The amount of soap in dishwater is so small as to be unworthy of consideration.

Dishwater usually contains free grease, and this may prove harmful to plants if applied frequently. Those who have lived in the country may recall that the area where dishwater was continually thrown out eventually became bare of grass and only supported the toughest of weeds.

It may be unsanitary to use suds from the washing of clothing. They may contain pathogenic bacteria if some member of the family is suffering from an intestinal ailment.

For these reasons we do not recommend the application of suds and dishwater to plants.



Above, cutworms at base of "cut" plant (life size)



Left, a wireworm (enlarged 3 ×)



1. Striped flea beetle. 2. Potato flea beetle. 3. Red-headed flea beetle. 4. Cabbage flea beetle. (All enlarged; see lines for life size)

General Feeders

Many insects feed upon a great variety of plants, and it is therefore necessary to protect almost every garden from them. Then there are insects, like aphids and flea beetles, which chiefly attack only certain kinds of related plants or groups of related plants, the control in all cases being the same. We treat the control of these under general feeders.

Aphids

These are the true plant lice. There are numerous kinds of them, and few plants are immune to their attacks. Since they are sucking insects, they must be controlled by contact sprays or dusts.

Spray or dust the affected plants with nicotine sulphate at the strength recommended under this insecticide (see table, page 6). Homemade nicotine spray (from cigarette and cigar refuse) may be used. Apply during the hottest part of the day (early afternoon).

Flea Beetles

There are many kinds of flea beetles, each limited to certain plants or groups of plants. They eat small holes in the leaves. All can be controlled in the same way. They may be recognized because they hop like fleas.

Apply Bordeaux mixture, which acts as a repellent. At the same time, it repels many other kinds of insects and is an excellent fungicide.

Cutworms

There are very many kinds of cutworms, which are the larvae of noctuid moths, and their habits are varied. The two that interest us most are the true cutworms, which cut off plants just above the surface of the ground, and the climbing cutworms. These insects bury themselves an inch or less in the soil during the day and come out at night to feed. Fortunately they like some other things more than they do vegetable plants, so it is possible to control them.

The following poisoned bait is very effective when properly applied:

Bran	5 pounds
Paris green	1½ ounces
Molasses	6 ounces
Water	2 quarts

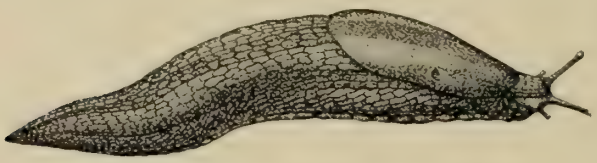
Scatter the Paris green over the top of the bran and stir with a stick or mix with the hand until thoroughly mixed. Dilute the molasses in the water. Pour some of the liquid into the bran and mix well. Continue until the mixture forms a loose, spongy mass when squeezed in the hand but does not all stick together when lifted in the open hand.

Take a handful of the mixture and spread it by a side-arm swinging

motion, allowing it to flow through the fingers. It is to be broadcast over the garden and in weed patches and hedgerows at least six feet beyond the garden limits. Application must be made at night, and the bait may be reactivated the second evening by a light sprinkling of water. The poison may be washed into the soil by a heavy watering. Keep chickens out of the garden for at least 48 hours, or until the poison has been washed away. If there is a heavy rain the first night, the application must be repeated.

Garden Slugs

These are not insects, but they often cause serious damage in the garden. They are most numerous in damp and shaded gardens. Under commercial conditions spraying may be necessary, but in the garden they may be controlled by placing pieces of board between the rows and destroying the



Above, a common garden slug (enlarged 2 ×)



Right, burdock borer in stem (life size)



Japanese beetle and its work (life size)

slugs found under them in the daytime. Some kinds of slugs are cultivated in Europe as food and are considered a great delicacy.

Wireworms

The larvae of the click beetles are common pests when grasslands have been dug over for the first time. They will attack cereals readily and, in the absence of these, garden plants. They are shiny, reddish-brown, wormlike creatures with hard shells. If many of them are found in digging the garden, control measures should be taken.

They may be trapped by burying pieces of potato about 2 inches under the surface and 10 feet apart. These pieces are dug up about once a week for a month and the wireworms destroyed. The same pieces of potato may be used 2 to 4 times. If shriveled or rotted, they should be replaced. If wireworms are not found after the second application, the procedure may be discontinued.

White Grubs

These are the larvae of June beetles and are readily recognized because they are curved so that the head and tail are close together. They are whitish in color, with a dark digestive tract visible in the middle line.

A usually satisfactory way of controlling them is to pick them at the time of digging and preparing the garden. Chickens and other birds thrive on them and will dig them out of loose soil. Starlings are particularly fond of them, both in autumn and spring. Since, in the absence of cereals, they will attack almost all roots, as many as possible should be destroyed while digging and cultivating. Potato tubers may be destroyed by them.

Grasshoppers

Grasshoppers are not normally a garden pest, but at times they may become so. They may be controlled by use of a bait similar to that employed for cutworms. The difference is that the molasses is replaced by 1½ ounces of salt and another pint of water is added, the bait being quite moist when applied.

Burdock and Potato Stalk Borers

These insects attack a great variety of plants, including many flowers with large stems. In the garden, corn and tomatoes are the most frequently attacked. The tops of the plants wither and die. A single caterpillar may in the course of its migrations cause the death of several plants or branches.

There is no very good control for these borers. The larvae usually migrate from weed patches, and the first evidence of their presence is the withering tips of plants. As soon as these withering tips are noticed the plant should be cut open. The culprit can usually be located at once and destroyed. The destruction of large

Right, the tarnished plant bug (insert is life size)



Below, the four-lined plant bug (insert is life size)



weeds and discarded stems of vegetable plants by allowing them to decay in the compost heap or by burning them in the autumn will greatly aid in control.

Tarnished Plant Bug

There is no satisfactory control for this small shiny bug (*Lygus pratensis*). It feeds on numerous kinds of plants; both adults and nymphs suck the juices. Weeds in and near the garden should be kept down all season. However, if weeds outside the garden are allowed to grow to any extent, they should not be cut, since they will attract the bugs from more valuable plants. Persistent spraying with nicotine might give control but the expense is too great in proportion to the damage that usually results.

Four-lined Plant Bug

This insect (*Poecilocapsus lineatus*) also attacks various kinds of plants in the garden, and it is sometimes a much more serious pest than the tarnished plant bug. It can be controlled by persistent spraying with a contact insecticide.

Other Plant Bugs

There are numerous kinds of plant bugs which vary in size and feeding habits. As a general rule they do not compare in the amount of damage caused with the two mentioned above. However, if present in large numbers they will cause some damage. Some of the smaller kinds are temporarily repelled by Bordeaux mixture, and contact sprays will aid in keeping their numbers down.

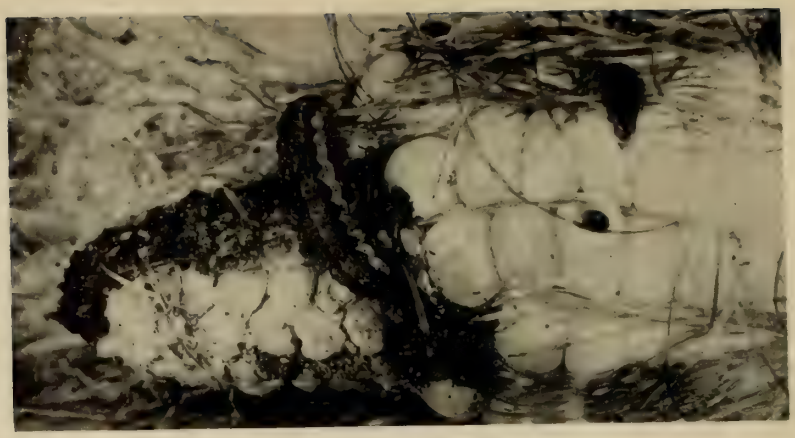
Japanese Beetle

The ravages of the adults of this insect are so well known that no further mention is needed. The beetles prefer certain kinds of crops (and even individual plants of these crops), so only those vegetables that attract many beetles need be sprayed. Hand picking will aid greatly but this may not be sufficient to prevent damage. Weeds around the edges of gardens will attract many beetles, which may then be gathered and killed.

Beetle traps aid in destroying the adults, but they should never be placed in the garden. If used, traps should be placed as far as possible from the garden. Otherwise those not caught in the trap will feed on garden plants. To be fully effective, traps must be used on a community scale.

Some Japanese beetle repellents have been developed but, never having used them, we cannot comment on their actual value.

The feeding of Japanese beetles may be greatly reduced by spraying with arsenicals. When these are used, the spray should contain lime at the rate of 4 pounds to 50 gallons of water since the additional white color has some repellent qualities. To secure best results spray the foliage of all plants in and near the garden upon which the beetles are observed feeding.



The corn ear worm at work (life size)



Work of the carrot rust fly maggot



Potato stem borer at work

Specific Feeders

Corn Insects

Corn has no place in the small victory garden, because it produces so little in proportion to the space required. However, it has its place in large gardens.

Corn is attacked by a goodly number of pests, and there is no completely satisfactory control for any of them. Japanese beetles are particularly attracted to the silk, and when this is gone they are apt to overflow onto other crops.

European Corn Borer

This is undoubtedly our worst pest. The caterpillars of this insect bore into all parts of the corn plant. Control is achieved by the complete destruction of old corn stalks and roots by approximately the middle of May.

Corn Ear Worm

This is the caterpillar of a southern moth that flies north each year and lays eggs on a number of different kinds of plants. On corn the worm usually works near the top of the ear, eating the kernels to the base. We have heard that this insect and the Japanese beetle can be kept from the ears of corn by placing a mothball at the top of the ear, within the leaves, while the silk is still green. It occurs to us that a pinch of tobacco dust (or rotenone dust, if available) might work. Both of these have some repellent qualities.

Carrot, Parsnip, and Celery Insects

There is only one serious pest of these crops. The others may be controlled by hand picking. This is the carrot rust fly. It attacks the roots of carrots in much the same way as the cabbage maggot attacks radishes and turnips. If there are wilted plants at the time of thinning, it is a sign that this insect is at work. Damage is often very serious. The carrot roots show rust-colored, irregular tunnels, caused by the burrowing larvae.

The control is the same as for the radish maggot (page 23).

The greenhouse leaf tier and the swallowtail caterpillar can be controlled in the small garden by hand picking. The former makes silken nets in the leaves of celery and other plants, while the latter is a rather large, green, black-banded caterpillar, the black bands enclosing yellow spots. The adult butterfly is quite beautiful.

Bean Insects

Beans are attacked by a number of different insects, the most serious pest being the Mexican bean beetle.

Damage by this insect is inclined to be spotty in the neighborhood of New York. Some patches may be very severely attacked, while others may be wholly free of the pest. It feeds chiefly on the under side of the leaves and may be well established before discovered.

The yellow eggs are laid on the under side of the leaves in clusters. But the presence of yellowish eggs does not prove the presence of the bean beetle, since other lady beetles lay similar groups of eggs, and their larvae are beneficial, since they feed upon aphids. Damage to the leaves is a sure indication.

Hand picking may be sufficient if the attack is light. If severe, either magnesium arsenate or sodium silica fluoride should be applied. Pyrethrum powder is also effective.

The banded flea beetle and the bean aphid are controlled by the sprays for flea beetles and aphids. (See page 13).



Mexican bean beetle at work (life size)



Cabbage maggots on root (life size)

All of these plants are attacked by the same insects, and control measures are practically the same for each. However, the flowers should never be sprayed with arsenicals. Once the cauliflower head forms, there should be no spraying until the leaves have been tied. In the small garden, hand picking will take care of the caterpillars on cauliflowers and cabbages. Rotenone and pyrethrum dusts give satisfactory control of the insects on these plants, but rotenone is not available at present. Many commercial growers use arsenicals in preference to the non-poisonous dusts. Since cabbages are never sprayed after reaching three-foruths of their growth and since the outer leaves containing spray are removed, there is no danger of poisoning. For the peace of mind of the user, the cabbages may be washed in a large pot of water or in running water. Poisons do not adhere well to these plants.

Cabbage Maggot

This is the worst pest during early stages of growth. The treatment consists of pouring a half cup of corrosive sublimate solution around each plant just after it is set out. This is repeated in about a week. When the plants become fully established and the roots harden, they are able to withstand attacks by one or two maggots. See description of the cabbage maggot under *Radish Care* (page 23).

Cabbage Butterflies

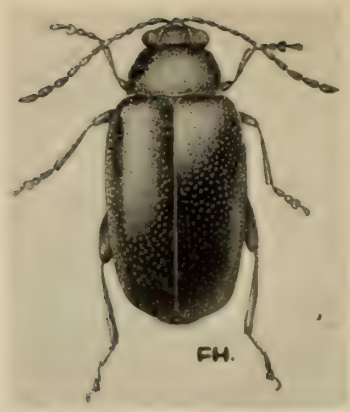
These insects, the imported and southern cabbage butterflies, attack a wide variety of plants and are the cause of serious damage to cabbages and cauliflowers. The larvae eat holes in the leaves and often bore into the heads of cabbages, frequently ruining them. The green leaves of cauliflowers are sometimes completely destroyed and the heads damaged from staining.

The caterpillars are of a soft, velvety-green color and grow to a length of 1¾ inches.

When only a few plants have been set out daily examination and hand picking should prove sufficient. The larvae live on the under side of leaves or hide between them. The presence of holes in the leaves usually indicates the presence of a caterpillar, and it should be searched for until found. Old holes will have a brownish rim and can be ignored. If there are too many plants to care for in this way, sprays or dusts should be applied to the under side of the leaves. A soap sticker must be added to the spray. Arsenicals may be used until about 3 weeks before the crop is harvested. Pyrethrum powder may be dusted on the plants every 10 days to 2 weeks.

Cabbage Looper

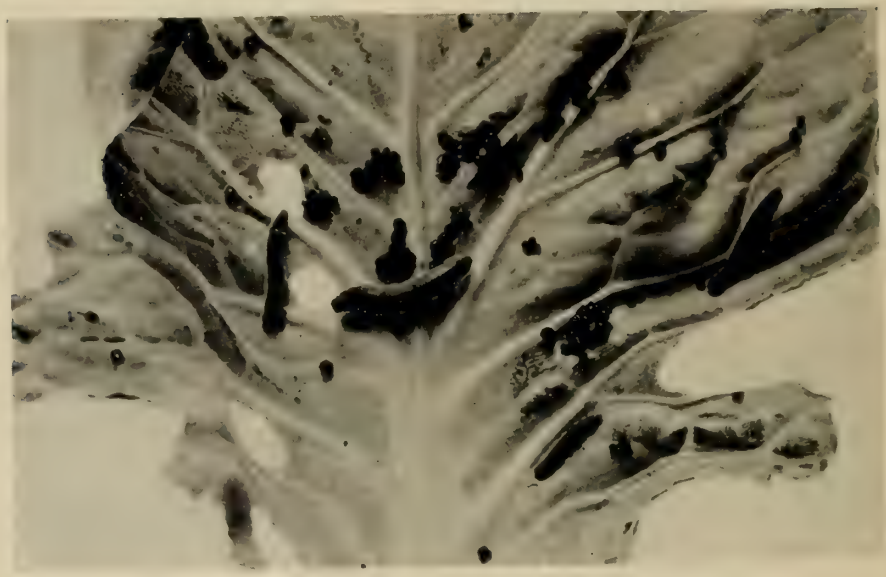
This insect causes injury of the same type as the cabbage butterfly, and treatment is the same. A large number of garden plants are attacked,



Cabbage flea beetle (enlarged 13 ×)



Young zebra caterpillars (life size) →



Larvae of the cabbage butterfly at work (life size)

including lettuce, beets, celery, and all crucifers. The caterpillars have white lines down the sides and back and move with a clumsy looping motion.

Zebra Caterpillar

Though not an annual pest, this insect when present does enormous damage. It may appear during the spring or in the autumn. The moth lays clusters of yellow eggs on the under side of the leaves, and the young larvae are gregarious. During this time they may be destroyed by removing the leaf on which they are feeding. When they grow older they separate and some of them find their way to other crops and flowers.

Control is the same as for the cabbage butterfly (page 21).

Diamondback Moth

This is a very small moth, with small, green caterpillars. They feed on the under side of the leaves, eating small holes through the epidermis. These show as small, brownish patches.

Control is the same as for the cabbage butterfly (page 21).

Striped Flea Beetle and Cabbage Flea Beetle

The striped flea beetle is small and black, with two wavy yellow lines down the back. The cabbage flea beetle is bright metallic green and is also quite small. All flea beetles hop when disturbed and can be recognized by this characteristic.

Apply Bordeaux mixture, which acts as a repellent.

Turnip Aphid and Cabbage Aphid

These are frequently serious pests of cabbage and cauliflower. The control is the same as is explained under *Aphid Control* (page 13). These insects also attack Brussels sprouts.

Radish Care

Most of the insects attacking cabbages attack radishes, but control measures are seldom necessary, with one exception—the cabbage maggot.

This is the most serious pest of the radish. The adult fly is markedly smaller than the housefly, but only a specialist could identify it. The eggs are laid either on the plants below the surface of the soil or in the soil close to the plants. They hatch in from 5 to 10 days. The maggots feed on the rootlets and later on the taproots, making winding, brownish tunnels and causing the root to become woody and unfit for use. Many of the young plants may be killed.

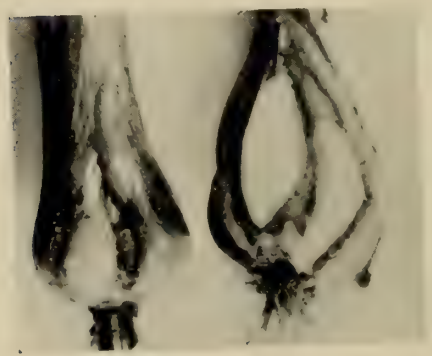
Control can be exercised when the plants are a few days old by watering with corrosive sublimate solution—about 1 cupful per foot. A large teapot or a small watering can (with the spout plugged enough to control the flow) may be used in applying. Repeat in about a week. If a metal container is used, it must be very thoroughly washed immediately after using; and do not use the teapot unless



Colorado potato beetle (enlarged 3½ ×)



Adult potato leaf hopper (enlarged 8 ×)



Onion maggots and work (life size)

it has been washed in a copious amount of hot water. Do not make any treatment after the roots begin to swell.

Turnip Care

One of the chief turnip pests is the cabbage maggot. Treatment is the same as described for this insect under radishes (page 23).

Almost all of the pests that attack cabbages attack turnips. The treatment is the same.

The turnip aphid and the cabbage aphid are frequently serious pests of the turnip, and the control is the same as is explained under *Aphid Control* (page 13).

Potato, Tomato, and Eggplant Insects

Potato Beetle

The Colorado potato beetle attacks other plants too, but it is chiefly a pest of potatoes. Potatoes are not a profitable crop for the small garden, but many week-end gardeners may have space for them. Almost as soon as the potato plants appear they are subject to attack, the foliage being eaten by both the adults and larvae, chiefly the latter. The clusters of orange eggs are usually laid on the under side of the leaves.

Hand picking of adults, larvae, and eggs will serve where the patch is small. In larger patches spray with arsenicals.

Potato Flea Beetle

This insect is often a serious pest of potatoes and tomatoes. The beetles eat small holes in the leaves. They are small and black, with brownish legs.

To control, spray or dust with Bordeaux mixture. Treatment with Bordeaux is an excellent practice, since the material is a fungicide and prevents the development of fungus diseases. It is to be particularly recommended where a garden is shaded and does not receive a good quota of sunlight.

Corn Ear Worm

This is a southern insect and cannot survive the winter in the northern states. But each year millions of the moths move northward; and since each female lays from 500 to 2,500 eggs, it is sometimes a serious pest. It frequently attacks tomatoes, boring into the fruits after they become half grown.

There is no known control, but infested tomatoes should be destroyed when the injury is discovered. The caterpillars will migrate from one fruit to another, and a single caterpillar may destroy several fruits in a bunch.

Tobacco or Tomato Worm

This insect attacks tobacco and is often a serious pest of tomatoes, feeding upon the foliage. It is, when fully grown, a very large, hairless caterpillar with a horn at the tail end. The color is green, with light V-shaped markings pointing toward the head end.

Control by hand picking. In larger patches use arsenicals.

Potato Leaf Hopper

These small, green, tapering, jumping bugs are frequently a serious pest of potatoes, tomatoes, and many other crops. The toxin they inject into the plant causes the leaves to curl and wither, this condition being known as "hopperburn."

Use Bordeaux mixture for control of this insect.

Pea Insects

Pea Moth

This is sometimes a serious pest in Eastern United States and Canada, especially where peas are grown year after year, but it is not likely to attack victory gardens unless close to commercial pea acreages. The eggs are laid at the base of the pea pod. The young larva bores its way in. Once inside, it feeds on the developing peas, sometimes attacking all of those in a pod, and usually causing a mildewy appearance.

Early varieties suffer little damage. The vines should be pulled and destroyed as soon as the crop has been harvested. By picking table peas cleanly when ripe the larvae are destroyed before they reach maturity. If they are a severe pest, peas should not be grown during the following year.

Pea Aphid

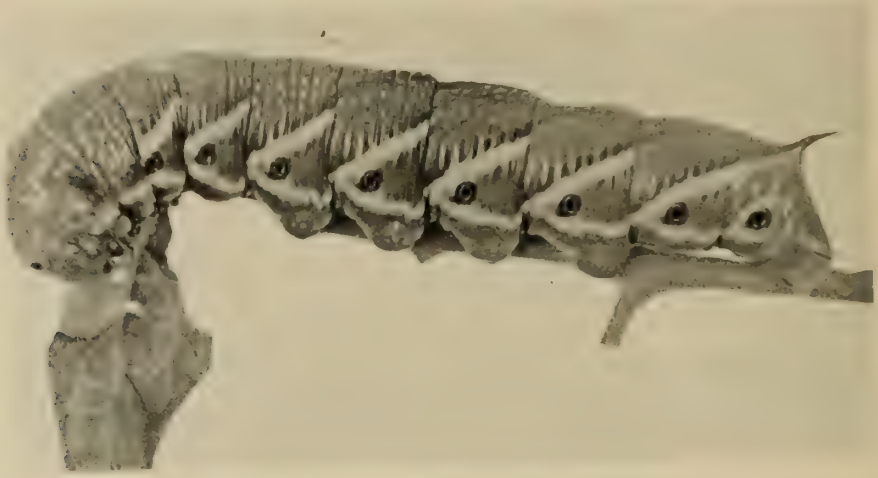
The pea aphid is often a very serious pest, especially if there is much clover in the vicinity. When very abundant,

this insect may kill the plants before the crop matures.

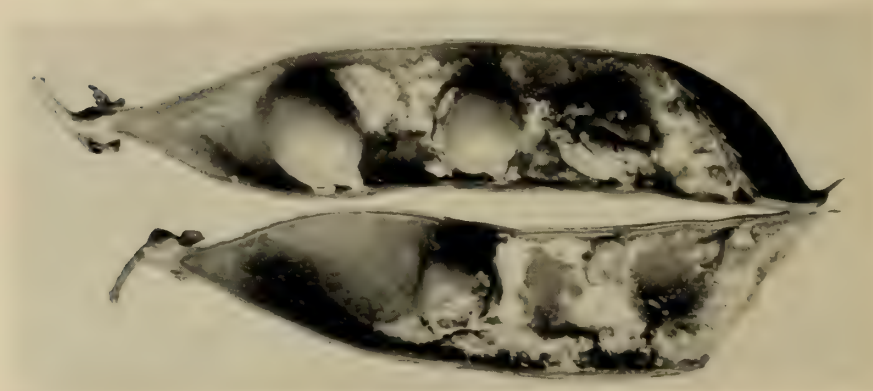
Spraying or dusting with nicotine sulphate is recommended for control of the pea aphid.

Pea Weevil

The larvae of this beetle feed within the peas and are not likely to be noticed. They are spread by sowing infested pea seed. Unless sown close to pea acreages the pest is not likely to be troublesome. The use of certified seed is an excellent safeguard and is the only precaution a small gardener can take.



The tobacco worm on a tomato plant (life size)



Larva of pea moth and injured peas

Onion Insects

Onion Maggot

This insect is related to the cabbage maggot, and the two look so much alike in all stages that only an expert can tell them apart. The eggs are laid on the onion stems below the surface of the soil, or in the soil, and the hatching maggots bore into the plants. When abundant they may destroy almost the entire crop. The first attack occurs about the time apple trees come into bloom, and they may continue throughout the summer. The young onion plants suffer most severely, older ones being able to withstand mild attacks, although suffering damage.

The treatment is the same as for the radish maggot (page 23).

Onion Thrips

This is an extremely small, feather-winged insect. The damage is caused by the feeding of the nymphs and adults. Silvery streaks on the onion leaves are a sign of this pest. In cool, wet summers the damage is seldom serious, but hot, dry seasons may result in extreme losses.

To control, spray with ½ pint of nicotine sulphate to 50 gallons of water, using 4 pounds of laundry soap as a spreader. The plants must be well soaked. Repeat if the thrips again become numerous.

When onion sets decay or onions rot they may be infested with various kinds of maggots and beetles. These are not to be considered as pests, but it is advisable to remove and destroy such onions to prevent the attraction of injurious species.

Cucumber, Melon, and Squash Insects

All of these plants are attacked by the cucumber beetle, but this insect is usually unimportant except on cucumbers.

Cucumber Beetle

Both the adults and larvae of this beetle feed on the leaves of cucumbers, and when numerous they may reduce them to mere skeletons. The orange or yellow eggs are laid in clusters on the leaves.

Control by hand picking in the small garden. Dust or spray with arsenate of lime in a large garden.

Squash Bug

This is mainly a pest of pumpkins and squash. The bugs live on the under side of the leaves. Both the adults and nymphs feed there. Since they are sucking insects, no holes are produced, but there are numerous light spots and eventually the whole leaf dies.

Since a large number of eggs are laid on one leaf and the bugs are more or less gregarious while young, the first sign of damage should be followed by an examination of the under side of all the leaves. If one finds eggs (laid in somewhat regular rows) or young

nymphs, the part of the leaf on which they occur should be destroyed. The adults and large nymphs may be picked off by hand. There is no other satisfactory control.

Melon Aphid

The melon aphid is very often a serious pest of melons.

For control, see *Aphid Control* (page 13).

Spinach Insects

A number of insects attack spinach, but few of them are important in the eastern United States.

Spinach Leaf Miner

The larvae of a fly mine within the leaves and frequently cause extensive damage. Although eating the larvae will cause no ill effect, most people discard damaged leaves.

To control, destroy all weeds, particularly docks and lamb's-quarters (pigweed). Pick and destroy all spinach leaves as soon as mines are noticed.

Aphids

Aphids and other insects also attack spinach. Aphid control may be advisable (page 13).

Right, squash bug (life size) and female laying eggs (enlarged $1\frac{1}{4}\times$)



Adult striped cucumber beetle (enlarged 5 ×)



Control of Ants

Ants are often quite a pest in gardens and their control is not always easy. As a class, ants will eat almost every kind of animal and vegetable matter but they have their preferences. Some like starches, others fats or oils, and others prefer sugars. Because of the great divergence of their preferences, it is difficult to prepare a mixture that will control all the ants in the garden.

The damage caused to plants is varied. Many plants may be destroyed by the building of nests close to them, and portions of the plants may be eaten. Then, some ants carry plant lice to the roots of plants, or from one part of a plant to another. They do this because they like the sweet juices excreted by the aphids. Damage is also caused by the building of large ant hills.

Control measures must be varied. For those ants that like sugar a sweetened bait must be used. A teaspoonful of arsenical or sodium fluoride should be added to a cup of syrup. The poisoned syrup may be poured on the soil near ant nests or placed in containers which may be mostly buried, with holes punched in the top in order to allow the ants to enter.

For control of other ants thoroughly mix a heaping teaspoonful of arsenical or sodium fluoride with 6 to 8 ounces of peanut butter. If there are no children or animals around, place small gobs of the mixture near the ant hills; otherwise place it in containers as above.

To destroy large ant hills, poke three or four deep holes in the hill and drop a tablespoon of calcium cyanide in each, then pack the top of the hill. This should be done in the evening when the ants are all in the nest.

All of these insecticides are poisonous and must be handled with great care.

There are many ant pastes and poisons on the market ready for use. Directions are contained on the packages. Whether they will prove effective in destroying the particular kinds of ants found in your garden can only be determined by trying them.

Beneficial Insects

Only a small percentage of insects are serious pests, and very many of the insects observed in the garden will be helpful in controlling those doing damage. In nature insects are chiefly controlled by other insects, and all pests have parasites. Sometimes these are sufficiently numerous to control the injurious kinds, but as a rule they are just one step behind the pests, and

only occasionally do they become sufficiently numerous to wipe out the insects causing damage.

Some of the most common beneficial insects in the garden are lady beetles and flower flies. The lady beetles feed on plant lice, both as adults and larvae, devouring enormous numbers of them. The flower fly larvae also feed on plant lice and meally bugs and often destroy whole colonies of them. The adult flies resemble wasps. Wasps are very valuable, since they catch other insects with which to feed their young. Bees, flies, and some moths—in fact, any insects that visit flowers—help to pollinate the flowers and thus are instrumental in producing crops. Ground beetles are almost all beneficial, feeding upon other insects; but since they are mostly nocturnal, they will not be seen very often.

We are unable, here, to devote much space to beneficial insects but we think that the gardener will soon learn to distinguish between the good and bad ones if they are abundant. If doubtful about an insect's habits, observe its actions. If it is a pest it will soon demonstrate the fact. Proper action can then be taken.

Control of Fungus Diseases

Although fungus diseases are beyond the scope of insect control, we include them here because the same spray, Bordeaux mixture, is used. In addition to this, there may be times when fungus will cause more trouble than insects.

Bordeaux mixture has long been used as a fungicide. Unfortunately Bordeaux will clog sprayers that do not have an agitator; but if a small hand sprayer is shaken frequently, little trouble will be experienced.

Prolonged periods of dampness are ideal for the development of fungus diseases. The use of Bordeaux will often prevent the loss of crops through fungus diseases and insect-carried viruses. It is because of this that its use is recommended along with arsenical sprays and dusts.

Mildews on plants may be prevented or controlled by dusting with sulphur. Sulphur used for dusting is of a fine quality; coarser sulphur should not be used.

Fungus diseases are spread in many ways, but the spores are carried chiefly by wind, by insects, and in manure.

Several commerical preparations are available for treating seeds to destroy fungus spores and for treating the soil against "damping off"—a germ disease of seed beds, which may destroy a fine looking crop of seedlings in a few hours. Directions for use of these materials are contained on the packages, which may be obtained from your seed dealer. Your State Botanist may be able to furnish additional information on the subject.

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An exceedingly useful handbook which puts into simple language the "How?" and "Why?" of mineral collecting and mineralogy.

BIRDS AROUND NEW YORK CITY. By Allan Cruickshank. *1942. 507 pages, 36 full-page illustrations. Price: $1.75 (cloth) plus 9c for mailing.*

A book indispensable to local bird students and of great interest to ornithologists at large. It tells when and where to find the birds of this region and gives a vast amount of information on their migrations, habits, and life histories.

General Guide

TO THE

AMERICAN MUSEUM of NATURAL HISTORY





The Museum is located on Central Park West from 77th Street to 81st Street and on 77th Street to Columbus Avenue. It may be reached as follows:

By Buses—8th Avenue or Columbus Avenue lines or 81st Street crosstown.

By Subway—6th and 8th Avenue to 81st Street (Museum) station.
7th Avenue to 79th Street station. Lexington Avenue to 77th Street station.
Take crosstown bus from East 79th Street to 81st Street and Central Park West.

The Main Entrance is on Central Park West at 79th Street. The South Entrance is on 77th Street Telephone: ENdicott 2-8500.

General Guide
to the Exhibition Halls of the
AMERICAN MUSEUM
of
NATURAL HISTORY

Compiled by
ROY WALDO MINER
Assisted by Members of the Museum Staff



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By The American Museum
of Natural History



THE AMERICAN MUSEUM OF NATURAL HISTORY, MANHATTAN SQUARE, NEW YORK

The buildings occupy most of the space between Central Park West, Columbus Avenue and 77th and 81st Streets. The main entrances are on Central Park West, through the Roosevelt Memorial, at three levels: street, vehicle (driveway beneath the steps), and subway. There is also an entrance on West 77th Street (center of block).

The Planetarium may be entered from West 81st Street (vehicle and foot) and through the Museum.

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ENTRANCE HALL ROOSEVELT MEMORIAL

THE THEODORE ROOSEVELT MEMORIAL

The Theodore Roosevelt Memorial, erected by the people of the State of New York in memory of the man whose name it bears, forms the main entrance to the Museum on Central Park West. Its graceful architecture follows a stately Romanesque design.

Passing through the central archway the visitor steps into the great Memorial Hall. Above the marble mosaic floor, rise walls of cream colored marble and limestone extending to an elaborate Corinthian cornice overarched by an octagonal coffered barrel-vault 100 feet above the floor. The central part of each wall is recessed and divided into three parts by two Roman Corinthian columns 48 feet high supporting the entablature. Three of these recesses are adorned with great mural paintings symbolic of the varied career of Theodore Roosevelt. On the walls, quotations from Roosevelt's writings are displayed in raised bronze letters.



MAIN ENTRANCE
ROOSEVELT MEMORIAL

The facade of the Memorial is adorned by four Ionic columns fifty-four feet high representing Boone, Audubon, Clark, and Lewis, pioneers in the early exploration of our country.

(Right) Sculptures of animals in low relief decorate the base of the columns

MURALS IN ROOSEVEL



(Above) Theodore Roosevelt stands over a Nubian lion and lioness. Several birds which completed the collections at the American Museum are included



(Left) Events in old Russian history are represented here through several historic personages of the period before 1000 A. D. At the bottom are shown the ancestors of the Roosevelt family, their names being inscribed above them. This and the opposite mural commemorate Roosevelt's part in the Russo-Japanese peace treaty of 1905

IEMORIAL HALL



(Above) In a tangle of gnarled trees, hemmed in by rocks, an African elephant is captured by a group of native hunters with shields and spears



(Right) Japanese spiritual beliefs are here represented in the figures of various gods and goddesses and in the first historic Japanese emperor, descendant of the Sun Goddess. At the bottom are the maternal ancestors of Theodore Roosevelt

GENERAL INFORMATION

The American Museum of Natural History is located in Manhattan Square and occupies most of the space between Central Park West, Columbus Avenue, 77th Street, and 81st Street. The main entrances are on Central Park West, through the Roosevelt Memorial, at three levels: street, vehicle (driveway beneath the steps), and subway. There is also an entrance on West 77th Street (foot and vehicle, center of block), and one on Columbus Avenue, near 77th Street (foot). (See Frontispiece.)

The Planetarium may be entered from West 81st Street (vehicle and foot) and through the Museum. Cars may be parked within the Museum square (enter from 81st Street) and at the curb on the streets surrounding the Museum square.

Admission

There is no charge for admission except for the Planetarium. The Planetarium, which was constructed by Reconstruction Finance Corporation funds, is a self-liquidating project, and admission will be charged until the loan has been repaid.

The Museum is open to the public from 10:00 A. M. to 5:00 P. M. daily except Sundays, Thanksgiving Day, Christmas, New Year's Day and July 4th, when it is open from 2:00 to 6:00 P.M.

Check Rooms and Information Desks

The main check room is located at the right as one enters the main entrance on the first floor of the Roosevelt Memorial (carriage entrance). Coats and packages may be left here. Wheel chairs for children and adults are available free of charge. There is also a checking room at the left of the 77th Street entrance. There is no charge for checking.

Information may be obtained at the check rooms and special information desks located on the main (2nd) floor of the Roosevelt Memorial, also at the right of the doorway at the 77th Street entrance. The latter is also the Education Bureau for the registration of instructors and students and the convenience of Members desiring guidance through the building by Museum instructors. Information concerning the exhibits or lectures may also be obtained here. Announcements of lectures and meetings of societies held at the Museum may be obtained here free of charge.

Museum Bookshop

The entrance to the Museum Bookshop is located near the 77th Street entrance to the Museum, adjacent to the elevators. Guide Leaflets and other Museum publications are sold here as well as postcards and souvenirs.

Books on natural history and its allied subjects by Museum authors and others in good standing are for sale here.

Bulletin Boards

The main bulletin board is at the right of Memorial Hall in the East Corridor, directly opposite the elevators. Here programs of lectures and meetings are displayed and also a directory to the exhibits on the various floors. Pictorial plans of the floors of the Museum are posted in the elevators and at convenient points throughout the Museum to aid in guiding visitors to the various halls.

Note

Due to constant rearrangements of exhibits in the halls, certain discrepancies may be noted at times between the arrangements in the halls and those in this volume. The alphabetical Pocket Guide and various guide leaflets procurable in coin machines and at the Bookshop will keep the visitor informed for the most part, while the most recent changes will be announced on the bulletin boards and in connection with the Bureaus of Information.

Sketching and Photographing

Artists and students are encouraged to draw from specimens on exhibit. Chairs may be had on application from the attendant. Amateur photographers may obtain permission to photograph in the halls of the Museum from the Roosevelt Information Desk. Professional photographers may obtain permission from the Photographic Division of the Department of Education.

Guiding

Free Service: This is offered to public schools and similar educational institutions and to Members of the Museum and their friends upon presentation of Members' inscribed tickets. In order to secure a guide, an appointment should be made in advance. Please state the day and hour desired, the number to be guided, and any special halls to be seen.

For appointments call ENdicott 2-8500, Extension 255.

Paid Service: This is provided for individuals not members of the Museum at 25 cents per hour for each person in a group. Minimum charge, $1.00.

Arrangements for groups from private schools must be made with the Bureau of Private School Service. The rate is $2.50 per hour. For appointments call ENdicott 2-8500, Extension 222.

Cafeteria

(Index Plan, page 16, Hall 12, Basement)

Convenient to the subway entrance in the Roosevelt Memorial Building is the Museum Cafeteria, which is operated as a Museum department for the accommodation of visitors. It is under the direction of a dietitian-manager.

The Cafeteria is open on all week days from 8:00 A.M. to 4:30 P.M. In winter it operates on Sundays from 2:30 to 5:30 P.M. It is closed Memorial Day, July 4th, Thanksgiving Day, and Christmas.

Breakfast and luncheon are served. There is also a sandwich counter and soda fountain.

Cafeteria for School Children

(Index Plan, p. 16, Floor I, Hall 11, Basement)

A cafeteria in the Education Building caters especially to school children and their teachers.

Library

(Take elevator to Fifth Floor)

The Library is located on the fifth floor of the Museum. It is devoted to works on natural history, exploration, and travel. It contains some 131,000 volumes, which comprise not only the important periodicals of our own and foreign countries but also all representative and standard works on zoology, physical anthropology, ethnology, prehistory, archaeology, geology, and paleontology. The collection on vertebrate paleontology forms the Osborn Library of Vertebrate Paleontology, founded by President Henry Fairfield Osborn.

The Reading Room of the Library is also located on the fifth floor, and is open to the public from 10 A. M. until 4 P. M. except on Sundays and holidays. The Library is also closed on Saturdays from June to September. Those interested in consulting the books and periodicals are welcome to do so during the available hours.

Publications

The publications of the Museum fall naturally into two groups, technical and popular.

The technical publications, comprising the *Bulletin, Anthropological Papers, Memoirs,* and *American Museum Novitates,* contain information gathered by the various expeditions or derived from the study of material collected. The *Bulletin* contains the larger scientific papers, covering records of explorations and collections of the Museum. The *Anthropological Papers* are devoted to researches in the study of man, supervised by the Museum's Department of Anthropology. The *Memoirs,* quarto in size, contain monographs, many of which require large illustrations. The *Novitates* include the shorter scientific contributions, descriptions of species, etc., which demand immediate publication. The scientific publications are distributed to libraries of scientific institutions and societies throughout the world, largely on an exchange basis.

The popular publications include *Natural History* Magazine, *Junior Natural History* (a children's magazine), *Guide Leaflets, Science Guides, Handbooks,* and *School Service Series.* The purpose of all these publications is to provide the public with accurate and interesting information in all fields of natural science.

Natural History is a copiously illustrated magazine containing articles of interest to the general public on explo-

ration, primitive man, amateur science, nature photography, and the interpretation of the world of nature. It contains the stories of museum expeditions and describes interesting and noteworthy exhibits. It is distributed as a privilege of membership in the Museum, or on subscription. For information regarding subscription to *Natural History* and *Junior Natural History,* inquire of the Membership Secretary, American Museum of Natural History, 77th Street and Central Park West, New York City.

The Museum's popular *Science Guides* deal with exhibits of particular interest and other subjects. More than 100 of these illustrated booklets have been published, and new ones are constantly being prepared. The *Handbooks,* thirteen of which have been issued, deal with themes related to the collections rather than to the particular objects exhibited. They are frequently used as textbooks.

A catalogue of the popular publications of the American Museum will be sent free on request. (Address: Popular Publications, American Museum of Natural History, 77th Street and Central Park West, New York, 24, N. Y.)

An Annual Report is issued yearly.

Education Building

Adjoining the West Corridor is the Bickmore Memorial Corridor, named in honor of Professor Albert S. Bickmore who inaugurated the work of the Museum with the schools. This leads to the Education Building, a five-story structure which contains the exhibits, offices, and classrooms of the Department of Education.

The Department of Education includes in its services practically all of the public relations work of the Museum. Intramurally it serves the public and private schools, colleges, and other educational institutions, as well as many other adult and youth groups and individuals through lectures, demonstrations, guiding, and other contacts. Beyond this, information and materials are sent to thousands of persons throughout the United States and neighboring countries through radio programs, news publicity, portable museums, slides, motion pictures, and cased collections.

On the first floor is **Education Hall** (Index Plan, page 16, Floor I, Hall 11), which is used for important temporary exhibits and special gatherings.

The second floor contains a **lecture hall,** seating 400, which can be divided into two smaller halls. This floor also contains one large classroom; the office of the Registrar, with whom instructors make arrangements when planning to bring classes to the Museum; and the office of the Associate Curator, who is in charge of the Teaching Staff and who should be consulted when guiding is desired.

On the third floor are **administration offices,** the **slide division,** and a **teachers' reference library.**

On the fourth floor is the office of the **photographic division,** with the photographic studios, and the **motion picture division,** with the offices of the circulating film library.

Membership

Through its explorations, The American Museum of Natural History is bringing together rare and valuable natural history collections from all parts of the world. Through its exhibition halls, its lectures, its work with school children and its publications, the Museum is making these wonders of nature easily accessible. The growth of this work is in large measure dependent upon the contributions of friends. Membership receipts are applied directly to these purposes. There are approximately twenty-six thousand members, who believe that the Museum is doing a useful service to science and to education, and are contributing to this work.

The Trustees invite you to lend your support by becoming a member.

Membership blanks may be obtained at the Education Bureau or Sales Booth, or from the boxes near the elevators.

Memberships may start at any time and will continue for a full year's period.

The various Classes of Membership, with the sums they contribute, are:

Endowment Members	$100,000
Benefactors	50,000
Associate Founders	25,000
Associate Benefactors	10,000
Patrons	5,000
Life Members	1,000

Fellows		$500
Supporting Members	(annually)	100
Contributing Members	"	50
Sustaining Members	"	25
Annual Members	"	10
Associate Members	"	4

Associate Members of The American Museum of Natural History enjoy the following privileges:

Current issues of NATURAL HISTORY — a popular illustrated magazine of science, travel, exploration and discovery, published monthly (except July and August), the volumes beginning in January and June.

A copy of the President's Annual Report on request.

An Annual Pass admitting to the Members' Room. This room is open every day in the year, is given over exclusively to Members, and is equipped with every comfort for rest, reading and correspondence.

Two Complimentary Tickets admitting to the Members' Room for distribution by Members to their friends.

In addition to these privileges, Members of the higher classes, to which all friends of the Museum are eligible, enjoy the following:

An Annual Pass admitting the Member and friends accompanying him to the Reserved Seat Section of the auditorium at Lectures for Members.

Two Single Admission Course Tickets to Spring and Autumn Series of Lectures for Members, to distribute to friends.

Two Single Admission Course Tickets to Spring and Autumn Series of Lectures for the Children of Members.

Current numbers of all Guide Leaflets, on request.

THE HISTORY AND WORK OF THE MUSEUM

The American Museum of Natural History was founded and incorporated in 1869 for the purpose of establishing a Museum and Library of Natural History; of encouraging and developing the study of Natural Science; of advancing the general knowledge of kindred subjects, and of furnishing popular instruction. For eight years its home was in the Arsenal in Central Park.

The cornerstone of the present building in Manhattan Square was laid in 1874 by President Ulysses S. Grant. In 1877, the first section (South Central Wing) was completed, and on December 22, 1877, it was formally opened by President R. B. Hayes.

In 1880, the educational work with the schools was inaugurated by Professor Albert S. Bickmore.

The Museum building is one of the largest municipal structures in the city, and has cost to date approximately $16,000,000. The South Facade is 710 feet in length, and the present East Facade, on Central Park West, is 600 feet. When completed, the building is designed to occupy all of Manhattan Square.

The building is largely erected and maintained by the City, through the Department of Parks. The Roosevelt Memorial section was the gift to the City by the State of New York as its monument to Theodore Roosevelt, and the Whitney Wing was erected jointly by the late Harry Payne Whitney and the City of New York. The Hayden Planetarium was financed by funds loaned by the Reconstruction Finance Corporation of the Federal Government. The annual City appropriation, known as the Maintenance Fund, is devoted to the care and upkeep of the building and the safeguarding of the collections.

The Museum is under the control of a self-perpetuating Board of Trustees, who give their services.

The scientific and educational work is carried on by some fourteen departments, each headed by a Chairman or Curator, under the leadership of the Director.

The funds through which specimens are purchased, exhibits constructed, explorations carried on, and scientific investigation conducted, are contributed by the Trustees, Members, and other friends. The scientific and popular publications of the Museum and the enlargement of the Library are also made possible through these contributions.

For the **instruction of the public** the halls of the Museum are devoted to the large series of exhibits which are described in this guidebook. These are supplemented by lectures and publications of a popular nature. On Tuesday afternoons a lecture is given by a staff member. On Wednesday and Saturday afternoons there are special motion picture

showings. An important course of evening lectures is given every Spring and Fall for the Members, also Saturday morning courses of Science Stories for children of Members. All lectures are illustrated by lantern slides and motion pictures, many of which have been secured by Museum expeditions.

Under the direction of the **Department of Education** of the Museum, extensive series of talks are given for the public school children of New York, and there are special showings of motion pictures on science, and social studies for students of high schools and colleges. Series of talks on Museum activities also are broadcast by the Radio Division.

The larger audiences meet in the main auditorium of the Museum on the first floor (Index Plan, p. 16, Floor I, Hall 7). This hall seats about 1400 persons and is completely equipped with stereopticons and apparatus for projecting silent and sound motion pictures. A second hall, similarly equipped, is on the fifth floor of the Roosevelt Memorial, and additional rooms on the floors below are used for smaller groups.

Scientific Societies meet at the Museum regularly and a number of their lectures are of general interest.

The New York Academy of Sciences, the oldest scientific society in New York City, founded in 1817, has its headquarters in the Roosevelt Memorial Building (Index Plan, p. 19, Floor IV, Hall 12a). It offers to scientists interested in pure research a forum for the discussion of their problems from a technical standpoint, and opportunities for the publication of their results.

BEHIND THE SCENES

The fifth floor of the Museum is devoted to the administrative offices, the offices and laboratories of the scientific departments and the library. On this floor are the work rooms of the Department of Vertebrate Palaeontology, where the skeletons of fossil animals are prepared and mounted, and the laboratory where the beautiful models of invertebrates are made. These, like the other laboratories, are of necessity not open to the public.

Scientific Laboratories and Study Collections. On the sixth floor of the African Section are the well equipped laboratories devoted to experimental biological research and to physiology and life histories based on the study of living animals.

Most of the scientific study collections are on the fifth floor. These are for the benefit of investigators and to preserve the evidences and records of our vanishing animal life and of the life and customs of primitive peoples.

The vast majority of the Museum's natural history specimens are in study collections to protect them from deterioration and for ready accessibility to scientific investigators. A careful selection is made of objects of greatest educational value and these form the basis of the Museum displays in its exhibition halls.

Work Shops. An important part of the Museum, not seen by the public comprises the work shops, located in the basement and provided with machinery of the most improved pattern. Here, among other things, are constructed the various types of cases used in the Museum. There is also a fully equipped printing establishment. In other parts of the Museum, also not open to the public, are the studios where the varied work of preparing exhibits is carried on by a large staff of artists and artisans. Here are cast, modeled or mounted the figures for the groups, while leaves and flowers are fashioned so accurately that they seem to grow and bloom. The latter are for accessories in the groups. Reptiles and amphibians are mounted and anatomical models of fishes are created in wax and other materials with painstaking care.

ENTERING THE MUSEUM

Fifty-eight halls of the Museum covering thirteen acres of floor space are now open to public exhibition. The visitor begins his journey through this immense treasure house of natural history from one of three directions: through the Roosevelt Memorial (see pages 6-8), through the Planetarium (see page 20), or through the South, or Seventy-seventh Street Entrance, which will now be described. A glance at the frontispiece will enable the visitor to get his bearings.

South Entrance Archway

Under the arch on Seventy-seventh Street, before entering the Museum doorway, may be seen the Bench Mark established by the United States Geological Survey in 1911, on which are inscribed the latitude and longitude, 40°46′47.17″ N., 73°58′41″ W., and height above sea level, 86 feet.

On the right is a **Glacial Pot Hole** from Russell, St. Lawrence County, New York, formed by an eddy in a stream beneath the melting ice of the glacier that once covered northern New York State. Pebbles, whirling around the eddy, cut and ground this hole, which is two feet across and four feet deep.

Glacial Grooves. On the left, is a large slab of fossiliferous limestone from Kelly Island in Lake Erie, near Sandusky, whose surface has been smoothed, grooved, and scratched by the stones and sand in the bottom of the vast moving ice sheet that covered northeastern North America during the Glacial epoch.

On either side of the archway are the two largest **beryl crystals** ever quarried. They were cut in Albany, Maine. These hexagonal crystals show the typical aquamarine color in their clearer portions.

Memorial Hall

(Index Plan, p. 16, Floor I, Hall 2)

One enters Memorial Hall, through the lobby from the South Entrance. In this hall are placed temporary exhibits of current interest. Many of these exhibits represent research in various departments of the Museum and recent results of exploration by Museum expeditions. The walls of this rotunda display the famous Covarrubias maps of the world which show the distribution of primitive art, natural resources, etc. Attractive reproductions of these maps can be purchased at the Bookshop, which is situated at the right of this hall.

Exploration and Geography

Exhibits showing equipment of polar explorations made in cooperation with the Museum are located in the corridor leading to the elevators. (Index Plan, p. 16, Floor I, Hall 2b).

Here are sledges with which **Peary** (1909) and **Amundsen** (1911) reached the North and South Poles, respectively; also souvenirs of the **Amundsen-Ellsworth** expeditions of 1925 and 1926. Maps of the Polar Regions show the routes of various explorers and the polar air flights.

In a room at the left end of this corridor is the large **Mainka seismograph** for recording earthquakes. This was presented to the New York Academy of Sciences by Emerson McMillin, and recently donated to the Museum by the Academy.

Lindbergh Plane. Another exhibit of historical interest for scientific exploration, now in the Hall of Ocean Life (Index Plan, p. 16, Floor I, Hall 10), is the airplane flown by Charles and Anne Lindbergh "north to the orient." This plane later took them by way of Greenland to Europe, thence down to Africa, across to Brazil, and up the Atlantic Coast to New York, a total distance of 30,000 miles.



Anthropology. Halls 1, 4, 6, 7a, and 8. (See also Floor II, Halls 4, 6, and 8; Floor III, Halls 4, 6, and 8; Floor IV, Halls 6 and 8.)
Auditorium. Hall 7. (See also smaller lecture rooms, Floor II, Hall 11; Floor III, Hall 12a; Floor V, Hall 12a).
Birds (Biology of). Hall 19. (See also Floor II, Halls 1, 2, and 19; Floor III, Hall 1; Floor IV, Halls 12a and 19.)
Birds, Local. Hall 12a.
Book Shop. Halls 2 and 2b. (See also Sales Booth, Floor I, Hall 18.)
Cafeteria. Hall 12 (Basement). For teachers and children: Hall 11 (Basement).
Check Rooms. Halls 2 and 12 (Vestibules).
Coral Reef Group. Hall 10.
Darwin Hall. Hall 5.
Education Bureau. Hall 2 (Vestibule).
Elevators. Halls 12a and 2b.
Eskimos. Hall 7a.
Fishes. Hall 9. (See also 12a.)
Forestry and Conservation. Hall 3.
Indians. Halls 1, 4, 6, and 8. (See also Floor II, Halls 4, 6, and 8.)
Invertebrates (Living). Halls 5, 10, and 12a.
Lindbergh Plane, Hall 10.
Mammals (Living). Halls 10, 12, 12a, and 13. (See also Floor II, Halls 3, 5, 9, and 13; Floor III, Halls 2, 3, and 13.)
Planetarium. Hall 18. (See also Floor II, Hall 18.)
Polar Exploration. Hall 2b.
Seismograph. Between Halls 1 and 2b.
Subway. Hall 12a (Basement).
Temporary Exhibits. Halls 2 and 11.
Tree of Life. Hall 5.



African Mammals. Hall 13. (See also Floor III, Hall 13.)

Akeley African Hall. Hall 13. (See also Floor III, 13.)

Anthropology. Halls 4, 6, and 8. (See also Floor I, Halls 1, 4, 6, 7a, and 8; Floor III, Halls 4, 6, and 8; Floor IV, Halls 6 and 8.)

Archaeology. Halls 4 and 6.

Asiatic Mammals. Halls 5 and 9.

Birds. Halls 1, 2, and 19. (See also Floor I, Halls 12a and 19; Floor III, Hall 1; Floor IV, Halls 12a and 19.)

Education. Hall 11. (See also Floor I, Halls 2 (Vestibule) and 11 (Temporary Exhibits); Floor III, Hall 11; Floor IV, Hall 11.)

Gold Ornaments. Halls 4 and 8.

Information Desk. Hall 12. (See also Floor I, Hall 2 (Vestibule).)

Lecture Room. Hall 11. (See also Floor I, Hall 7; Floor III, Hall 12a; Floor V, Hall 12a.

Mammals (Living). Halls 3, 5, 9, and 13. (See also Floor I, Halls 10, 12, 12a, and 13; Floor III, Halls 2, 3, and 13.)

Mexican and Central American Indians. Hall 4.

North American Mammals. Hall 3. (See also Floor I, Hall 13.)

Panda, Giant. Hall 5.

Planetarium. Hall 18. (See also Floor I, Hall 18.)

South American Indians. Hall 8.



African animals. Hall 13.
African natives. Hall 8.
Akeley African Hall (Balcony). Hall 13.
Amphibians. Hall 9.
Anthropology. Halls 4, 6, and 8. (See also Floor I, Halls 1, 4, 6, 7a, and 8; Floor II, Halls 4, 6, and 8; Floor IV, Halls 6 and 8.)
Apes, Monkeys, and Lemurs. Hall 2.
Asiatic Natives. Hall 8.
Birds. Hall 1. (See also Floor I, Halls 19 and 12a; Floor II, Halls 1, 2, and 19; Floor IV, Halls 12a and 19.)
Comparative Anatomy. Hall 4.
Education. Hall 11. (See also Floor I, Halls 2 (Vestibule) and 11; Floor II, Hall 11; Floor IV, Hall 11.)
Health (Biology of Public Health). Hall 12a.
Insects. Hall 5. (Also Floor I, Hall 12a.)
Jumbo Skeleton. Hall 3.
Lantern Slides. Hall 11.
Lecture Rooms. Hall 12a. (Also Floor I, Hall 7; Floor IV, Hall 12a; Floor V, 12a.)
Mammals (Living), Biology and Evolution of. Halls 2 and 3; Akeley Hall Gallery, Hall 13. (See also Floor I, Halls 10, 12, 12a, and 13; Floor II, Halls 3, 5, 9, and 13; Floor IV, Hall 2a.)
Petrology. Hall 7a. (See also Floor IV, Hall 1.)
Primates. Hall 2.
Reptiles (Living). Hall 9. (See also Floor I, Hall 12a; Basement, Hall 12.)
Whale Model. Hall 3. (See also Floor I, Halls 10 and 12a.)



Anthropology. Halls 6 and 8.
Audubon Art Exhibit. Hall 12a.
Bird Art Gallery. Hall 19.
Camel, Evolution of. Hall 3.
Dinosaurs. Halls 5, 9, 12a, and 13.
Drummond Collection of Jade. Hall 6.
Education. Hall 11. (See also Floor I, Halls 2 (vestibule) and 11 (temporary exhibits); Floor II, Hall 11; Floor III, Hall 11.)
Elephants, Mammoths, Mastodons. Hall 2.
Fishes (Fossil). Hall 5.
Fossil Exhibits:
Fishes. Hall 5.
Invertebrates. Hall 1.
Mammals. Halls 2 and 3.
Reptiles. Halls 5, 9, 12, and 13.
Gems and Minerals. Hall 4.
Geology. Hall 1. (Also Floor III, Hall 7a.)
Horse, Evolution of. Hall 3.
Horses, (Modern, including famous racers). Hall 2a.
Invertebrates (Fossil). Hall 1.
Jade, Drummond Collection. Hall 6.
Lecture Room. Hall 12a. (See also Floor I, Hall 7; Floor II, Hall 11; Floor III, Hall 12a; Floor V, Hall 12a.)
Library. Take elevator (Hall 12a or 2b) to Floor V.
Mammals (Fossil). Halls 2 and 3.
Man, Origin of. Hall 2. (See also Floor III, Hall 4.)
Minerals and Gems. Hall 4.
Motion Pictures (sound and silent films for circulation). Hall 11.
New York Academy of Sciences. Hall 12a.
Philippine Natives. Hall 8.
Prehistoric Animals. Halls 2, 3, 5, 9, 12a, and 13.
Reptiles (Fossil). Halls 5, 9, 12a, and 13.
South Sea Natives. Hall 6.



HAYDEN PLANETARIUM AT NIGHT

ASTRONOMY AND PLANETARIUM

(Index Plan, pp. 16-17, Floors I-II, Hall 18)

The Hayden Planetarium, with its main entrance on Eighty-first Street and Central Park West, constitutes the Museum's Hall of Astronomy. The principal feature of the building is the projection instrument. Installed in the centre of a hemispherical dome seventy-five feet in diameter, this amazing instrument is made up of a series of projectors which throw on the artificial sky the fixed stars, the sun, moon, planets, and the Milky Way. Since there are no pillars to intercept the light, the illusion of the depth of space is perfect.

Plans for an astronomy section of the Museum were first developed in 1925 by the late Howard Russell Butler, in collaboration with the Museum staff and the architects, Trowbridge and Livingston.

In the spring of 1933 the Trustees of the American Museum formed a separate corporation under the Reconstruction Finance Corporation to construct and equip such a planetarium. Mr. Charles Hayden of New York, after whom the building is named, generously donated both the projection planetarium instrument and the Copernican planetarium on the first floor.

The sky shows are scheduled as follows:

Weekdays: 2:00, 4:00, 8:30 P.M.

Saturdays: 11:00 A.M., 2:00, 3:00, 4:00, 5:00, 8:30 P.M.

Sundays and Holidays: 2:00, 3:00, 4:00, 5:00, 8:30 P.M.

Admission (including tax):

Mornings and afternoons	30¢
Evenings	40¢
Children, at all times	20¢



THE SUN GOD PURSUES THE MOON GODDESS ACROSS THE SKY. Mural painting by Charles R. Knight

As the visitor enters the first-floor corridor he sees opposite the entrance a large mural painting by Charles R. Knight, based on astronomical legends and myths of the American Indians. The myths represented were selected from the Blackfoot Indians. The central figure depicts the Sun God pursuing the Moon Goddess across the sky. In the upper right may be seen the Pleiades as conceived by the Indians, and in the upper left the Big Dipper and the North Star. On a mountain in the lower left corner sits the Ancient or Original Man sending the little animals down below the water to bring up mud out of which he makes the world, in accordance with a widespread creation legend.

On the second floor of the Planetarium are hung the astronomical paintings of the late Howard Russell Butler, of Princeton, the most striking of which are the three eclipse subjects over the southeast entrance to the Planetarium dome representing eclipses observed in 1918, 1923, and 1925, in Oregon, California, and Connecticut respectively.

Notable also among Mr. Butler's paintings is the strange and beautiful "Lunar Landscape," showing the sky as it would appear from the surface of the moon, with the earth as a heavenly body shining in the distance. The two paintings of the red planet Mars, as seen from its inner and its outer moons, show the so-called canals and other surface features. The exquisite painting of the Northern Lights as seen in August, 1919, from the coast of Maine, is one of the most beautiful of all astronomical paintings.

On the first floor is the Hall of the Sun, with its animated model of the solar system, forty feet across. Here we see the sun and six of the nine known planets—part of that family of heavenly bodies to which our earth belongs—as though we were viewing them from a great distance, from far out in space.

In the center of the circular room, sus-

pended from the ceiling, is a large luminous globe representing the sun itself. At increasing distances from this are the small globes of those planets nearest the sun: little Mercury, closest of all; Venus, veiled by a dense layer of bright clouds; Earth, with its seas and continents and its attendant moon; Mars, long disputed as a possible abode of life; Jupiter, the giant planet, bigger than all the rest rolled together; and Saturn, surrounded by its unique and beautiful rings.

The miniature worlds of this complicated machine not only revolve about the sun but rotate on their axes as the real planets rotate, moving always at the correct relative speeds.

The three planets farthest from the sun, Uranus, Neptune and Pluto, are not included in the apparatus because of their enormous distances.

Before each sky show in the planetarium dome, a preliminary talk is given in the Hall of the Sun. This talk is arranged to prepare the audience for the show they will see later upstairs. Each month it is changed to relate the planetary motions to the subject of the month.

The floor of the Hall of the Sun is enriched by a reproduction in terrazzo by Victor Foscato of the famous Aztec Calendar Stone in Mexico City. The original symbolizes the Sun which was, to the Aztecs, the most important of the heavenly bodies adored by them, and commemorates the four past epochs of the world and the one in which they lived. A cast of the original is to be found in the Mexican Hall on the second floor of the Museum.

The projection apparatus itself is installed on the second floor. It is shaped like a huge dumb-bell about twelve feet long, at each end of which is a large globe. These two globes contain the projectors of the fixed stars, one globe for the northern hemisphere of the sky, the other for the southern. Lantern slides so shaped that their images fit together when projected on the dome, make a complete picture of the starry heavens without overlapping and without gaps.

The representation of the fixed stars, including the Milky Way, is a comparatively simple part of the performance of the instrument, and yet it is certainly the most impressive. When the light is gradually dimmed, bringing on the darkness the stars are "turned on," giving a realistic illusion of the starry heavens.

The projection of the stars is controlled by a switchboard arranged like a desk-top with switches reminiscent of organ-stops. These turn the stars on and off. On the vertical part of the board are rheostats controlling the brightness of the stars and other celestial objects. With this instrument before him, the lecturer has over two thousand combinations at his command.

The apparatus has several different speeds, all many times faster than the real motions. This makes it possible to condense a very long astronomical story, so as to give in a few minutes a clear understanding of the seemingly intricate workings of the heavenly bodies.

The American Museum of Natural History collection of meteorites exhibited in the first floor corridors of the Planetarium is one of the largest in the world, comprising many specimens from huge masses like the Ahnighito (Greenland) meteorite, weighing 36½ tons, the largest meteorite in any museum, to thousands of small specimens like gravel comprising the study collection.

Meteorites are those extra-terrestrial bodies which fall to the earth from outer space. They consist of stone or metal, or a combination of these materials, and vary in size from dust particles to immense masses weighing tons. When passing through the earth's atmosphere these celestial objects are usually accompanied by manifestations of light and sound, and are known as shooting stars, meteors or fireballs. The term meteorite is applied only after they reach the ground and form a part of the earth.

Also in the first floor corridor is a remarkable collection of sun-dials, compasses, and astronomical instruments. This fine loan collection covers almost the entire range from ancient Chinese instruments through the fine metal instruments made in the middle-centuries in France and Germany, down to the very accurate compasses which play such an important part in modern navigation.



THE GREAT PROJECTION INSTRUMENT IN THE HAYDEN PLANETARIUM. This is the principal feature of the Planetarium building. Through its means the illusion of the heavens with the fixed stars and planets, following their apparent paths through the sky, is thrown upon a dome-shaped ceiling

GEOLOGY

(Index Plan, pp. 18-19, Floor III, Hall 7a; Floor IV, Hall 1)

The geological exhibits in the Museum are found in the Hall of Geology and Invertebrate Paleontology on the fourth floor, and on the third floor in the Hall of Petrology and Economic Geology.

Geology is the science of the past and present conditions of the earth. It enters into a consideration of the materials composing the earth, their composition, structure, distribution, and the physical changes they have undergone or may be undergoing. It deals with minerals and their arrangement and association in rocks and ores. It considers the occurrence, distribution, origin and history of the principal kinds of rocks, namely: igneous, sedimentary and metamorphic. It especially treats of the order of deposition and sequence of the stratified beds of rock, for these, together with the fossils found in many of them, give not only a chronological account of the events in the development of the earth's crust, but reveal the succession of life forms on the earth. The processes and agents which are at work within and on the surface of the earth, tending to modify it, such as rock weathering, underground waters, glaciation, diastrophism, vulcanism, metamorphism and gradation, are forces which are acting to-day and have been acting throughout the long history of the earth. The processes of change are most conspicuous where air, water and rocks are in contact with one another.

The field of geology is so broad that, for convenience and specialized study, it has been divided into numerous branches. The three principal branches are: (1) Structural geology, treating of the form, arrangement and internal structure of the rocks; (2) Dynamical geology, dealing with the causes and processes of geologic change; (3) Historical geology, which, aided by other sciences, aims to give a chronological account of the events in the earth's history.

Geologic Exhibits in the Hall of Geology and Invertebrate Paleontology

(Index Plan, p. 19, Floor IV, Hall 1)

To illustrate the three principal branches of geology, pictorial models of fifteen areas within the United States have been installed. These show the most evident and striking results of geologic forces acting through long periods of time. Beginning at the left near the entrance, they are as follows:

1. The model of the Bright Angel section of the **Grand Canyon** of the Colorado River, Arizona, illustrated on page 27.

2. A model of the **Niagara Falls** region, built to the same scale as the Grand Canyon, showing the falls and the seven-mile gorge which its waters have cut in ancient sedimentary rocks, and also the more recent glacial deposits covering the surface.

3. The **Potomac River** section, showing the Appalachian Mountain type of folding and erosion, with rivers adjusted to the softer rocks of Silurian and Devonian age.

4. The **Van Horn,** Texas, region, featuring fault block structures and a bolson basin — a depression nearly enclosed by mountains.

5. **Yellowstone Park,** Wyoming, including the geyser basins and the Rocky Mountain type of topography.

6. The **Pike's Peak,** Colorado, model, showing the mountain, composed of red granite, and the bordering stratified deposits of the Great Plains near Colorado Springs.

7. The Caldera of **Mt. Mazama,** five miles in diameter and two thousand feet deep, which has been made a National Park and has become famous under the name Crater Lake. Numerous outpourings of lava suggest the structure and history of the ancient volcano.

8. The **Standing Stone** district near Monterey, Tennessee, showing normal subaërial erosion and the production of sink holes in horizontally disposed beds of limestone and shale.

Continuing on the opposite side of the hall are the following models:

9. The **Mt. Tom-Mt. Holyoke** district of western Massachusetts, showing a great trough, traversing the ancient crystalline rocks, which was filled with the sands, muds and intruded lava flows in Triassic time.

10. The **Watkins Glen-Seneca Lake**



THE ERUPTION OF MT. PELÉE ON THE ISLAND OF MARTINIQUE. This was one of the most destructive eruptions known in history. It took place in the year 1902 and completely destroyed the city of Saint Pierre causing the death of 30,000 inhabitants. From a painting in the Hall of Geology

district of central New York State, showing moraine deposits and other features due to the advance and retreat of the continental ice sheet over a region of horizontally bedded limestone, sandstone and shale. In the background appears a representation of the retreating ice-front of the last glaciation.

11. The **Mt. Washington,** New Hampshire, region, showing typical glacial cirques and other glacial phenomena in an area of crystalline rocks.

12. The picturesque **Yosemite Valley** in the Sierra Nevada Mountains of California, with U-shaped glaciated valley bottom and precipitous marginal walls.

13. The **San Francisco,** California, model, exhibiting a portion of the Pacific Ocean, the Coast Range with volcanic and sedimentary rocks, the California trough or inner lowland with plains bordering San Francisco Bay, and the famous strait, Golden Gate.

14. The **New York City** model, showing the Hudson River estuary; the crystalline pre-Cambrian rocks on Manhattan Island to the north and east; the Triassic rocks west of the Hudson, which include red sandstone, shale and conglomerate, the Palisades diabase and the Watchung basaltic ridges; also the glacial drift and terminal deposits on Long Island, on Staten Island, and in New Jersey.

15. The last model in this series is one of **Porto Rico** and the **Virgin Islands,** showing a narrow submerged platform and neighboring vast oceanic "deeps."

Facing the entrance of the Hall is a geological relief model of the **lower Hudson River region** from New York City nearly to Albany. A relief map of the **Panama Canal** occupies the center of the aisle toward the rear.

In each of the eight alcoves on the west side of the hall is placed a model showing a stage in the **geographic development of the North American continent.** Those represented fall within the following geologic periods: Cambrian, Ordovician, Silurian, Devonian, Permian, Cretaceous,

Eocene and Pliocene. The present known surface, evidenced by outcrops of fossiliferous rock of the age represented, is shown in black. From this and other data the extent of the ancient epicontinental seas has been determined and the shore-lines marked. The present oceanic depths are shown in relief, while the various marine basins and elevated land masses on the continent are marked with colors without relief. The present outline of North America, shown on each model, indicates that the geography during the first six periods was quite different from that of to-day.

At the rear of the hall, to the right, is the **Copper Queen Mine** exhibit. A large model, 18 by 12 feet, shows on a miniature scale the surface features and buildings over four of the principal mines belonging to the Copper Queen Consolidated Mining Company of Bisbee, Arizona, while a painted background represents the surrounding mountains and the town of Bisbee. The sides of the model give vertical sections to the depth of about 1,200 feet, illustrating the geology of the area and showing the general manner of getting out the ore and hunting for new deposits.

Specimens of ore, minerals and rocks from the mine and the adjacent country illustrate the geology of the region, including velvet malachites and a great block of malachite and azurite weighing about three tons taken from the original "Queen" mine.

Opposite the Copper Queen exhibit is a display of **caves and cave material,** including a reproduction of part of a beautiful cave discovered at the Copper Queen mine. It was formed by the dissolving action of water traversing joints in limestone, and its walls, roof and bottom were afterward coated with incrustations, stalactites and stalagmites of calcite, some of which are dazzlingly white while others are colored green with copper salts or pink with manganese compounds.

Near by is a reproduction of a chamber in Weyer's Cave, Virginia. Here the heavy rainfall of the region is probably the principal factor in producing a greater wealth of stalactite and stalagmite growth than in the Copper Queen Cave.

The Hall of Petrology or Rock History

(Index Plan, p. 18, Floor III, Hall 7a)

The new Hall of Petrology, on the third floor, is approached through the Hall of North American Birds (III, 1). It has been designed to present the visitor and student with a concise and graphic visualization of the basic processes of rock formation, as well as the application of the science of Geology to modern life and the industrial world.

At the entrance to the Hall is a series of paintings and exhibits depicting the most spectacular and best-known volcanoes in the world—Mt. Lassen, Mt. Pelée (see page 25), Vesuvius, Sakurajima and others—and a map showing the world distribution of volcanoes.

Leading from this section the Hall exhibits products of magma, or molten rock, from deep in the earth. The various products of volcanic eruptions, such as ash, pumice, lava, volcanic bombs, gaseous deposits, are also shown.

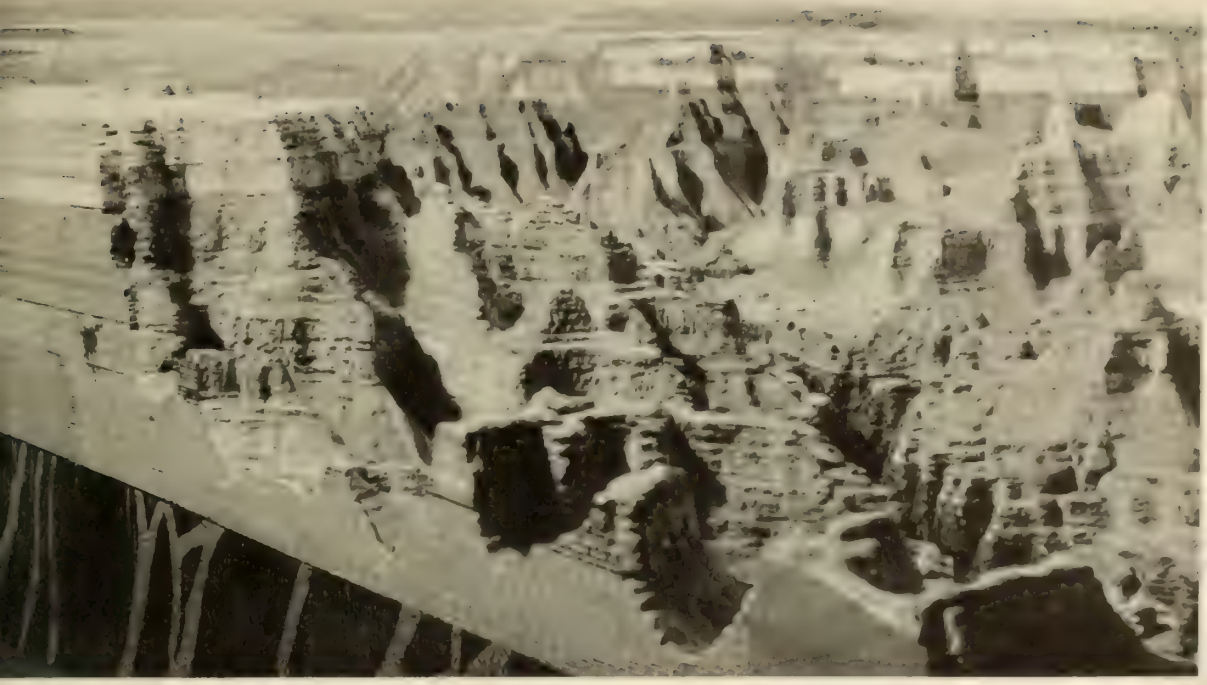
The following cases and diagrams show the result of igneous intrusions of molten rock into cold rocks at various levels and the types of rocks so formed — how man is able to glean the precious stores of gold, silver, copper, iron, radium and lead as a result of these cooling processes.

In the succeeding exhibits the visitor observes the breakdown of primary rocks by wind and water and then the deposition in seas and valleys to build up a new class of rocks — the sedimentary rocks — forming sandstones, shales and limestones.

Exhibits describing structural geology show how rocks can be folded and broken when the surface of the Earth is being molded into new mountain chains and new seas. The third group of rocks shown is that of the metamorphic rocks — those created under such terrific pressures and heat that an entirely new class of crystalline rocks is made.

Further economic geology is shown by exhibits of ore-bearing rocks. The various processes that produce coal and oil are illustrated, as well as the history and types of coal and their distribution in the United States.

The nature of the interior of the earth is shown in another case.



MODEL OF THE GRAND CANYON OF THE COLORADO

Miniature Model of the Grand Canyon of the Colorado

(Index Plan, p. 19, Floor IV, Hall 1)

Showing General Appearance and Geological Section

The Grand Canyon of the Colorado River is represented in this model in such a manner as to show not only the chief features of this magnificent example of erosion but also the successive layers of rock which make up its geological structure. The Grand Canyon is more than three hundred miles long, thirteen miles wide and a mile in depth from the brink of the canyon to the river bed. For countless ages the layers of gneiss and granite were formed. Then the region sank beneath the sea and successive layers of sandstone, limestone, and shales were deposited upon it to a depth of more than 4,000 feet. After several millions of years these rocks were raised above sea level, and erosion by streams, wind and frost took place. A second time this region was submerged beneath the sea and more marine deposits were laid upon it. Similar changes continued to take place throughout the ages until about a million years ago, when the whole plain was again above sea level and the excavation of the present canyon was started, which is still progressing.

This relief model represents a region about sixteen miles wide from west to east and thirteen miles from north to south.

The Grand Canyon was first seen by white men early in the sixteenth century, when Cardenos and his twelve companions were guided by Hopi Indians to some now unknown point on the rim. He remained there four days looking in vain for a way to descend. Cardenos had been sent out by de Coronado to find the wonderful river whose existence had been communicated to de Tovor, another member of the famous exploring expedition. The first sure traverse of the Canyon was made in small boats in the summer of 1869, by Major J. W. Powell with eight brave companions.

The head of the Bright Angel Trail is 6866 feet above mean sea level, while the river in front of this spot is about 2400 feet above the sea, making the canyon about 4460 feet deep below an observer standing in front of the hotel. The opposite brink of the canyon, however, is eight thousand feet above sea level so that the total depth is more than one mile.



JAPANESE ROCK CRYSTAL ELEPHANT. This polished rock crystal sphere is mounted on an elephant also carved from a single piece of clear rock crystal of transparent colorless quartz. The work is done in the Japanese manner

MINERALS AND GEMS

(Index Plan, p. 19, Floor IV, Hall 4)

The Morgan Memorial Hall of Minerals and Gems is entered through the Hall of the Age of Man on the fourth floor. This hall, through the gift of Mr. George F. Baker, has been remodeled to contain the General Collection of Minerals and the Morgan Gem Collection.

Of these, the General Collection of Minerals is without question one of the finest to be found in the world, ranking with that of the British Museum and the Jardin des Plantes. It is composed chiefly of the well-known Bement Collection, presented to the Museum in 1900 by the late Mr. J. Pierpont Morgan. Although remarkably complete in its representation of most of the mineral species known to science, this collection is especially noteworthy for its assemblage of splendid examples of the commoner and more widely distributed minerals.

The visitor should begin with the first of the cases, to the left of the entrance, and proceed from left to right along each side of every case, advancing through the south row of cases and returning through the north row. The different species are divided within the case by narrow strips between the mounts. The large and imposing specimens are arranged in wall panels around three sides of the Hall, and constitute a Key Collection. To the right of the entrance will be found cases in which the subject of Crystallization is presented by a series of models. This series, as well as other explanatory exhibits in adjoining cases, constitutes an important key to the understanding and appreciation of the general mineral collection.

The cases occupying the middle of the hall contain the Morgan Gem Collection, comprising the valuable series of gems and precious stones also presented by J. Pierpont Morgan, to which have been added from time to time noteworthy specimens given by other friends of the Museum.

The Morgan Collection includes the series of American gems assembled by Tiffany and Company for the Paris Exposition of 1889 and the series of foreign gems and gem stones exhibited at the Paris Exposition of 1900.

The installation comprises examples of those minerals which are used for gems and for ornamental objects and consists of rough, uncut material and of fashioned gem stones and carved objects. All of the specimens exhibited have been chosen with great care and are not only thoroughly representative but include many examples which are unique in size, beauty of coloring and perfection of execution, reflecting the very highest standards of the art of the lapidary. Here again explanatory labels are used to give meaning and weight to the exhibit, not merely as a display of jewelry material but as a complete visual exposition of the knowledge of gem stones.

Among the notable gems included in this collection are:

The **De Long Star Ruby,** one of the finest gems of this kind in the world, and the **"Star of India,"** the largest star sapphire in the world (Case III).

The fine **engraved emerald,** bequeathed by Miss Cockcroft-Schettler (Case IV).

The **Morgenthau blue topaz** (Case VI).

The **Vatican Cameo,** carved from essonite garnet (Case VIII).

The **oriental cat's eye,** and the **Russian alexandrite gems** (Case XI).

The Betts bequest **opal pendant** (Case XII).

The **kunzite gems** (Case XXIII).

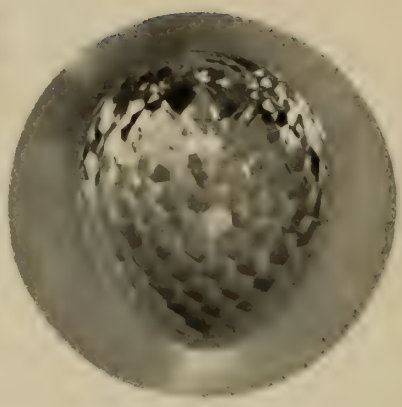
The **Tonnelier chalcedony figurine,** the gift of Charles Lanier (facing the Morgan Tablet).

The Emerald

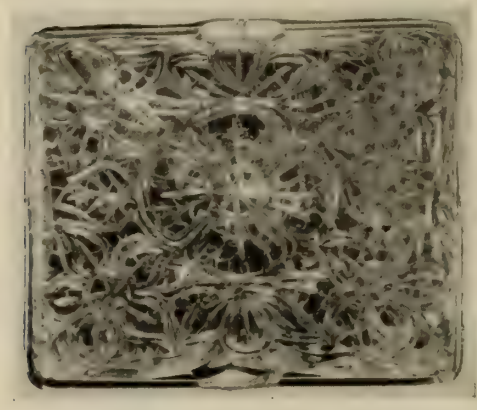
The Emerald affords a striking example of a gem that owes its beauty of color to an impurity which is non-essential to the mineral of which it is a variety. The fine green color so desirable in this stone, which is a variety of the mineral Beryl, is entirely due to a very small amount of chromium.

The refractive index of emerald is very low, a fact which accounts for the lack of brilliancy and "fire" which characterizes the cut stones. Since little or noth-

BLUE TOPAZ FROM JAPAN. Egg-shaped, brilliant cut, with 440 facets and weighing 1,463 carats. Natural size.
Gift of M. L. Morgenthau.



ENGRAVED EMERALD ORNAMENT. This engraved emerald weighing 87.64 carats was originally from Muso, Colombia. Sir Purden Clarke placed this gem, probably of Delhi cutting and used as a head ornament by some Hindu prince, in the period of the Mogul domination of India (1526-1739). Gift of Elisabeth Cockcroft Schettler



ing can be gained by using a brilliant cutting for emeralds, the step cutting is almost universally used. Flawless emeralds are extremely rare, the imperfection usually taking the form of cracks and inclusions which greatly impair the transparency of the stone. It is this rarity of desirable stones of the first quality which renders the emerald the most costly of precious stones, the value of the best gems being between three and four times that of diamonds of equal weight.

The principal source of emeralds is the Muso Mines of Colombia, a locality which was furnishing gems to the aborigines at the time of the Spanish conquest.

The Topaz

Although gem crystals of the mineral topaz are found in a variety of yellow, orange and blue shades, the deep orange-yellow color, resembling sherry wine, is generally accepted as typical. To such an extent is this true that we find the word topaz often incorrectly used to describe other yellow stones, as for example, oriental topaz, (yellow sapphire) and false topaz (quartz). A colorless variety is occasionally used as an imitation diamond in cheap jewelry, its brilliancy surpassing that of cut glass.

The hardness of topaz, greater than that of amethyst (quartz), is almost equal to that of emerald. It is therefore eminently fitted for the high rank which it takes among semiprecious stones. Gems of fine color rank in value with choice aquamarines of equal weight.

Although topaz is obtained from a great number of localities, the best colored stones come from Brazil.

The Edith Haggin De Long Star Ruby

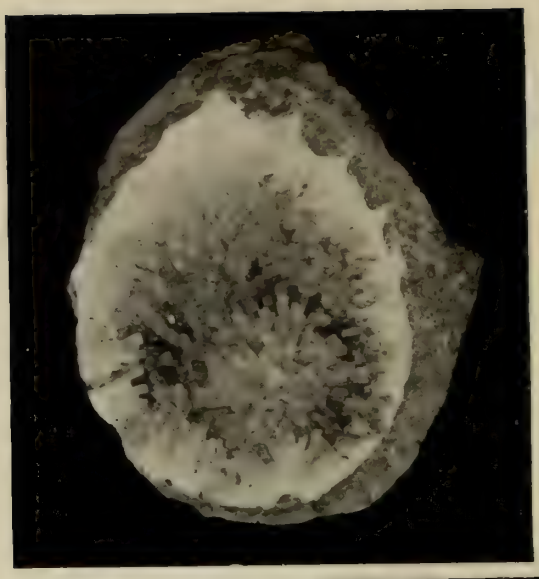
This is the finest and largest gem of its kind known to exist in the world. Its color is a peculiar milky crimson, best described as "orchid red." The curious and beautiful six-rayed star which glows within the gem results from a myriad of minute hollow tubes which are distributed throughout the crystal with great regularity, parallel to its six sides. When cut *en cabochon*, so that the rounded dome arches over this hexagonal pattern



THE EDITH HAGGIN DE LONG STAR RUBY. This unusually beautiful star ruby is reputed to be the largest and finest gem of its kind in the world. It weighs 100 carats and was discovered in one of the ruby mines of Burma. Its color is a peculiar orchid-red. A remarkable six-rayed star glows within the gem, formed from a myriad of minute hollow tubes which are distributed throughout the crystal with great regularity, parallel to its six sides. The stone has been cut in a rounded dome, the shape which best reflects the light from the interior. It was presented to the Museum by Mrs. George Bowen De Long, in whose honor it is named

of cavities, stones of this kind reflect the light from the interior as a six-rayed star and consequently they are termed star rubies and star sapphires. This gem, weighing 100 carats, was discovered in one of the ruby mines of Burma and was presented to the Museum by Mrs. George Bowen De Long, in whose honor it is named. It is unique among star rubies, being larger than any other remotely approaching it in quality.

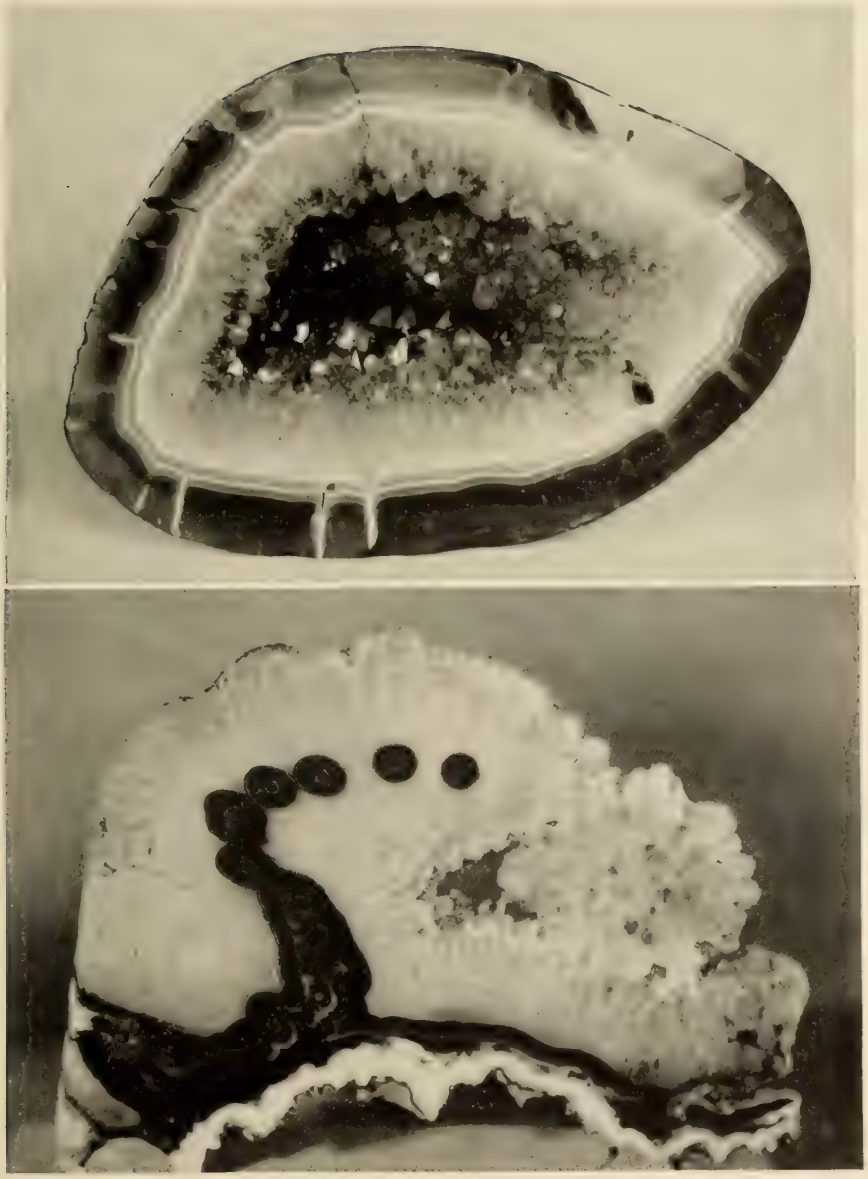
Geology and Minerals of New York State. Two cases illustrating these features are exhibited on the first floor of the Roosevelt Memorial (Index Plan, p. 16, Floor I, Hall 12). One case shows the principal minerals characteristic of the State and the localities where they may be found. The other demonstrates the extent of the sedimentary, igneous, and metamorphic areas within the borders of the State.



TWO FINE SPECIMENS OF NATROLITE FROM THE MUSEUM'S COLLECTION OF MINERALS. The specimen of natrolite to the left came from Lippa, Bohemia. The slender orthorhombic crystal-like prisms, nearly square in cross section, form a radiating group somewhat resembling clusters of organ pipes



(Right) NATROLITE FROM WEST PATERSON, NEW JERSEY. Besides the tetragonal crystals, finer hair-like crystals in the form of long slender silky needles radiate from a central nucleus suggesting a fluffy seed ball of the dandelion



TWO QUARTZ GEODES FROM URUGUAY. A geode is a nodule of stone having a cavity lined with crystals of mineral matter. The rock cavity in the upper figure was encrusted in successive layers of agate deposited from the silica dissolved in the water which circulated through it. Crystalline quartz was ultimately added in a final layer. This quartz, colored with a purplish hue, is known as amethyst



ASBESTOS *(left)* is a variety of serpentine, a hydrous magnesium silicate consisting of white, gray, or green fibers which are easily separated and can be spun or filtered to make non-combustible fabrics



STIBNITE *(to the right)* is a sulphide of the semi-metallic substance known as antimony. The slender orthorhombic prisms are made up of many crystals joined parallel to each other. This mineral is the chief source from which antimony is obtained. The specimen illustrated came from Inyo, Japan



A FOSSIL AMMONITE of 150,000,000 years ago, related to the ancestors of the common nautilus

(Index Plan, p. 19, Floor IV, Hall 1)

Closely connected with geology, and indeed almost inseparable from it, is paleontology, or the study of ancient forms of life. The sedimentary rocks have been found, on examination, to contain in many places remains of plants or animals, which may closely resemble, but more often appear very different from, those now living on the earth. The order of deposition of the beds, with the oldest at the bottom and the youngest at the top, and the imbedded fossil forms of life, give the geologist the means of constructing a chronological chart, or time scale, depicting the eras, periods, epochs and formations of geologic time. There are five eras: Archaeozoic (Primal life), Proterozoic (Primitive life), Palaeozoic (Ancient life), Mesozoic (Medieval life), and Cenozoic (Modern life). The rocks of the Archaeozoic era have not afforded recognizable fossils, although the indirect evidence is sufficient to assume that life existed at that time. In a few localities (as in Montana and southern Australia), fossils have been obtained from the rocks of late Proterozoic age. Beginning with the



(Right) FOSSIL SEA SCORPION: a eurypterid *(Eusarcus scorpionis)*, probably ancestral to the scorpion



FOSSIL BRACHIOPODS OF THE SILURIAN AGE. Primitive shelled creatures somewhat resembling clams externally but not related to them

basal period of the Palaeozoic era, the Cambrian, well-preserved fossils indicate that most of the various classes of invertebrate life were in existence, though represented by primitive forms. The earliest known records of invertebrate life are fossil fish scales from the upper Ordovician rocks of Colorado.

FOSSIL INVERTEBRATES

As installed in the Hall of Geology and Invertebrate Paleontology the exhibits of fossil invertebrates occupy alcoves on either side of the hall. The specimens in the cases on the left are arranged to illustrate historical geology, beginning at the entrance with the Pre-Cambrian rocks and advancing regularly through the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, Eocene, Oligocene, Miocene, Pliocene, and Pleistocene periods of geologic time. Most of the specimens shown are from Ameri-

A FOSSIL INVERTEBRATE OF ANCIENT SEAS. *(Below)* A well-preserved crinoid, or sea-lily, a flower-like animal related to modern star-fishes



TRILOBITES *(below)* flourished in Devonian seas and became extinct millions of years ago. Perhaps related to the ancestors of modern Crustacea





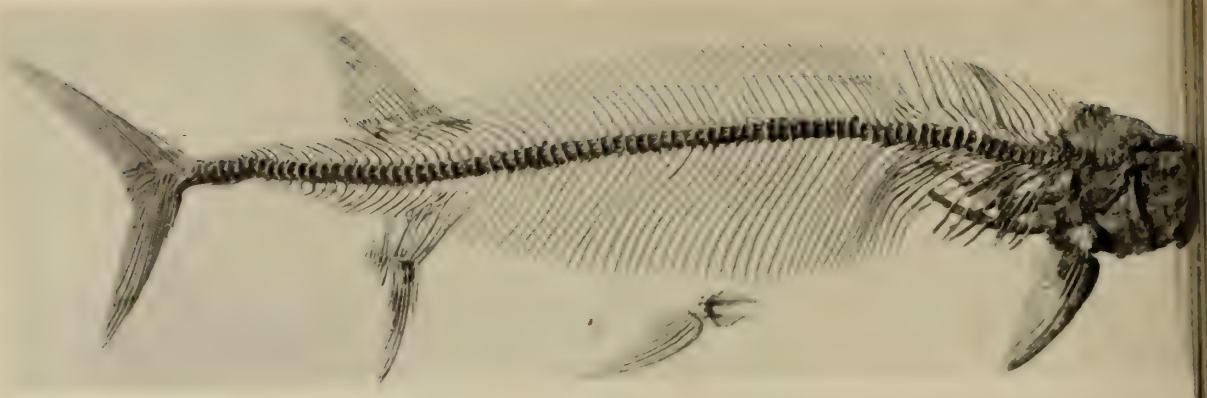
Portion of a large rock crowded with brachiopods *(Spirifer vanuxemi).*

can localities. The examples shown are those particularly characteristic of the various horizons, the object being to give an idea of the general character of the life of different periods of the world's history.

The specimens on the right side are arranged to illustrate the classification and relationship of the plants and animals of past geologic times. The series starts with the invertebrate animals, beginning with the lower, or simpler, forms and continuing to the highest. The specimens have been drawn from foreign and domestic localities and different geologic ages. The exhibits illustrate at a glance the wide range of variation which each group has taken during geologic time.

In the center of the hall are the stump and part of the roots of a large tree from an anthracite coal mine under Scranton, Pennsylvania. Millions of years ago this tree grew upon the top of a thick swamp deposit of decaying vegetation, which ultimately became a valuable bed of coal. The stump, left in the roof of the mine when the coal was removed, fell to the floor years after the gallery had been abandoned, and was discovered only through the chance visit of a miner.

Two stumps of a large fossil tree-fern of Middle Devonian age from Gilboa, New York, appear in the first alcove on the right. These specimens were obtained from a quarry opened in connection with the great engineering work of the New York City Board of Water Supply. They are the oldest trees known.



GIANT BULLDOG FISH *(Portheus molossus)*. This huge fossil fish came from the chalk beds of Kansas. It is 15 feet, 8 inches long and about 80 million years old

FOSSIL VERTEBRATES

(Index Plan, p. 19, Floor IV, Halls 2, 2b, 3, 5, 9, 12a, 13)

Fossils are the petrified remains of plants or animals that lived at some past period of the earth's history. Sometimes, as with the bones of the great Irish elk, the objects have been buried in swamps or bogs, and in a few rare instances, as with the mammoth and woolly rhinoceros, entire animals have been preserved for thousands of years in ice or frozen mud. Fossils are found in localities where the dead animals or plants were gradually buried under layers of sediment to such a depth and for so long a time that they finally became petrified. Later, through upheaval and erosion, they were again brought to or near the surface of the earth. Petrifaction is the slow replacement of animal or vegetable material by such minerals as carbonate of lime or silica, which are carried in solution by the underground waters. The process is very slow and for this reason the soft parts usually decay before they can be petrified. Fossil beds are found in every continent. In our own country, Texas, Montana, Wyoming and the Bad Lands of South Dakota are famous for their large fossil beds, and many of the finest and rarest fossils in the Museum were obtained in these localities.

As it takes thousands of years for the various layers of earth to accumulate over the bones, and for the latter to become hardened to rock, the study of fossils and of the strata in which they are found is an important aid in determining the age of the earth and the succession of life thereon. The skeletons exhibited in these halls are of animals which lived from 10,000 to 250,000,000 years ago, while in the Hall of the Age of Man specimens of fossil man are exhibited dating from 10,000 to 1,250,000 years ago.

To prepare a specimen for exhibition, the matrix in which the bones are embedded is carefully chipped away and the missing parts restored in cement and plaster. The bones are then assembled as in life. In the specimens on exhibition, the restored parts differ in color from the original skeleton and can readily be distinguished.

The Museum's collections of fossil vertebrates are probably the finest in the world, considering not merely numbers but especially variety, quality and perfected methods of preparation and exhibition.

The walls of several of the halls are adorned by mural paintings by Charles R. Knight, portraying some of the more striking animals of the various geologic ages, culminating with those contemporary with early man in Europe and America.

The Museum's exhibits of fossil vertebrates are all displayed on the Fourth Floor.

Fossil Fishes

(Index Plan, p. 19, Floor IV, Hall 5)

The Bashford Dean Memorial Exhibit of Fossil Fishes occupies the Southeast Tower of the Museum on the Fourth Floor.

One enters the exhibit below a model

of the jaws of an enormous fossil shark about 9 feet across, with the actual fossil teeth set in place. This monster, closely related to the modern White Shark or "Man-eater," is estimated to have been 46 feet long.

At the left of the entrance is a bronze portrait plaque of Professor Bashford Dean (1867-1928), former Curator of Fishes at this Museum, where he studied especially the armored fishes of past ages, a fine series of which are included in this exhibit.

The huge fish shown as if swooping down from the ceiling is a model of *Dinichthys,* one of the great armored fishes from the Devonian of Ohio. The original skull, shown near by, is one of the prizes of the collection.

These curious forms, of numerous species, all had a pair of joints connecting their bony head-pieces with their shoulder plates. This gave rise to their group name, "Arthrodira," or "joint-necks." They were the tyrants of their day and were doubtless unpleasant neighbors to the nearly naked fin-fold sharks, their contemporaries. These latter show a very interesting stage in the evolution of the fins, in which the skeletal rods supporting the primordial fin-fold, had begun to push outward well beyond the line of the body. Even our own arms and legs are only greatly enlarged and modified fin-paddles.

At the far end of the exhibit is a "fossil aquarium" — restorations in miniature of various well-known forms from the Old Red Sandstone of Cromarty, Scotland, as they would have appeared in life, more than three hundred million years ago.

They include *Pterichthys* and its allies of the distant past, when they were nearing the time of their extinction. Others represent "spiny sharks" and "joint-necks" which were then dominant groups. A third lot includes advancing types, the "fishes of the future," the ancestors of the swarming teleost or bony fishes familiar to us today. But the most interesting group are the "lobe-fins," which were the direct ancestors (or close relatives) of the later land-living vertebrates.

At that far-off period of the earth's history, some of the lobe-fins, or primitive ganoids, through their ability to suck atmospheric air into a moist internal sac or lung, finally emerged from the water at the edge of the swamps, using their stout paired paddles to push themselves up into the muddy margins. These evolved the first limbs, and thus the adventurous air-breathing fishes began the conquest of the land and became the ancestors of all land vertebrates, including man.

The great fish on the rear wall, opposite the entrance, is *Portheus molossus,* popularly called the Giant Bulldog Fish. It comes from the chalk beds of Kansas. This huge creature is 15 feet, 8 inches long and about 80,000,000 years old. At that time, Kansas, now in the midst of the continent, was submerged under a shallow sea, somewhat like the Mediterranean, swarming with giant sea-lizards, huge marine turtles, and great and small fishes of many kinds.

In the first alcove to the right, a wall-chart illustrates the stream of fish life in geologic sequence, 500,000,000 years of fishes. It gives at a glance the basic arrangement of the specimens shown, notable among which are Ostracoderms from the Silurian and Devonian, the giant *Portheus,* and the saw-finned *Protosphyræna* from the Cretaceous of Kansas.

Fossil Reptiles

The dinosaurs, the largest of the fossil reptiles, form the most spectacular part of the Museum's paleontologic exhibits. The more primitive reptiles and also those of such other groups as the fossil alligators and turtles are also well represented in the Museum's collections. They are displayed in a series of halls on the fourth floor of the Museum as described on the following pages.



THE GREAT THUNDER LIZARD *(Brontosaurus excelsus)*. A huge water-living dinosaur of the Jurassic Period



A CARNIVOROUS DINOSAUR AND ITS PREY (*Allosaurus* and *Brontosaurus*). Though not as large as *Brontosaurus*, the *Allosaurus* was a formidable carnivorous reptile which, it is believed, was able to devour its larger but more sluggish dinosaur contemporary

Hall of Jurassic Reptiles

(Index Plan, p. 19, Floor IV, Hall 13)

The skeleton which dominates the center of the hall is that of the great *Brontosaurus*, or Thunder Reptile. This big-bodied, small-headed dinosaur has massive limbs, whose joints, capped in life with cartilage, indicate that he lived in swamps and in the edge of streams where the great weight of his body—25 to 30 tons—would be supported in the water.

Near *Brontosaurus* is *Allosaurus*, "apparently turned into a fossil while munching on the tail of a defunct relative of that big beast." Looking closely, one sees that the tops of the vertebrae of the victim are scored with grooves where some millions of years ago they were marked by the teeth of the flesh-eating dinosaur that destroyed it.

In a case to the left of the *Brontosaurus* skeleton is displayed the skeleton of a splendid example of *Stegosaurus*. This curious creature had a small head with a brain weighing only a few ounces. The arching backbone is composed of vertebrae that increase rapidly in size toward the middle of the back where they are enormous, showing cavities for spinal ganglia many times the size of the brain. A double series of huge bony plates are supported upright along the back and were probably defensive in character. At the end of the tapering tail are four long spikes of bone with which the *Stegosaurus* is supposed to have struck at its enemies, the formidable weapons being brought into play as the dinosaur rotated upon its hind legs.

In the cases toward the end of the hall are found ancient Permian reptiles: *Diadectes*, *Edaphosaurus*, and *Dimetrodon* from North America, *Dicynodon*, *Moschops*, and *Scutosaurus* from South America and Russia. Here also are reptiles of Triassic age, some of them ancestral to the later dinosaurs. The most ancient types of land vertebrates, the stegocephalian amphibians, are also displayed in this portion of the hall. Eryops is of particular interest.

Corridor of Marine Reptiles

(Index Plan, p. 19, Floor IV, Hall 12a)

This corridor, situated in the Roosevelt Memorial, occupies the angle to the right as one comes out of the Jurassic Hall. Here, on the wall, are displayed slabs of stone containing well-preserved fossils of the marine ichthyosaurs, including one specimen with embryos visible through the ribs as they lay in the body cavity of the mother. A fine specimen of *Plesiosaurus* is exhibited in a case at the foot of the staircase leading to the fifth floor. As one turns the angle of the corridor, on the wall to the left, are slabs containing fossil foot-prints somewhat resembling huge bird tracks. These are in reality impressions left by great Cretaceous carnivorous dinosaurs which ran on their hind legs (see skeletons in the Cretaceous Hall adjoining).

Hall of Cretaceous Reptiles

(Index Plan, p. 19, Floor IV, Hall 9)

The Cretaceous Age was the period of the greatest development of dinosaurs, and at the close of that period they became extinct. At one end of the hall the visitor sees towering over his head the great *Tyrannosaurus*, the Tyrant Dinosaur, his head eighteen feet above the ground. This was the largest carnivorous land animal of all time and it doubtless preyed upon contemporaneous dinosaurs, many of which were protected by defensive armor and menacing horns.

A huge skeleton of *Triceratops* is seen at the left. This monstrous-headed creature doubtless fed on coarse vegetation. His jaws terminated in a great horny beak for clipping off branches and rushes, and his back teeth were adapted for shearing them. These teeth were arranged in several rows and as they wore out they were replaced by new teeth which pushed from below. The squatty fore-legs enabled the animal to lower his head to the ground with ease, and the big bony "frill" with which the skull terminated above the neck served as a protection, as a counterweight to the head and jaws, and as an attachment for powerful muscles.

To the right of *Tyrannosaurus* are the dinosaurs *Trachodon* and his relatives, *Corythosaurus* and *Saurolophus*. Note

STEGOSAURUS, a strange armored dinosaur of the past





THE DUCK-BILLED DINOSAUR *(Trachodon).* These remarkable herbivorous dinosaurs had a curious duck-like bill used in gathering aquatic vegetation. They walked on their hind legs or swam about using the tail as a propeller



A GIANT FLYING REPTILE *(Pteranodon longiceps)*, the largest known American flying reptile with toothless skull and long, pointed beak

how the two large *Trachodon* skeletons are equipped with flat, expanded jaws which enabled them to strain out and crush the water plants and mollusks growing abundantly in the Cretaceous swamps where they fed. Nearby is a remarkable *Trachodon* specimen in which the impression of a large part of the skin has been preserved, giving us definite information as to the covering of the animal.

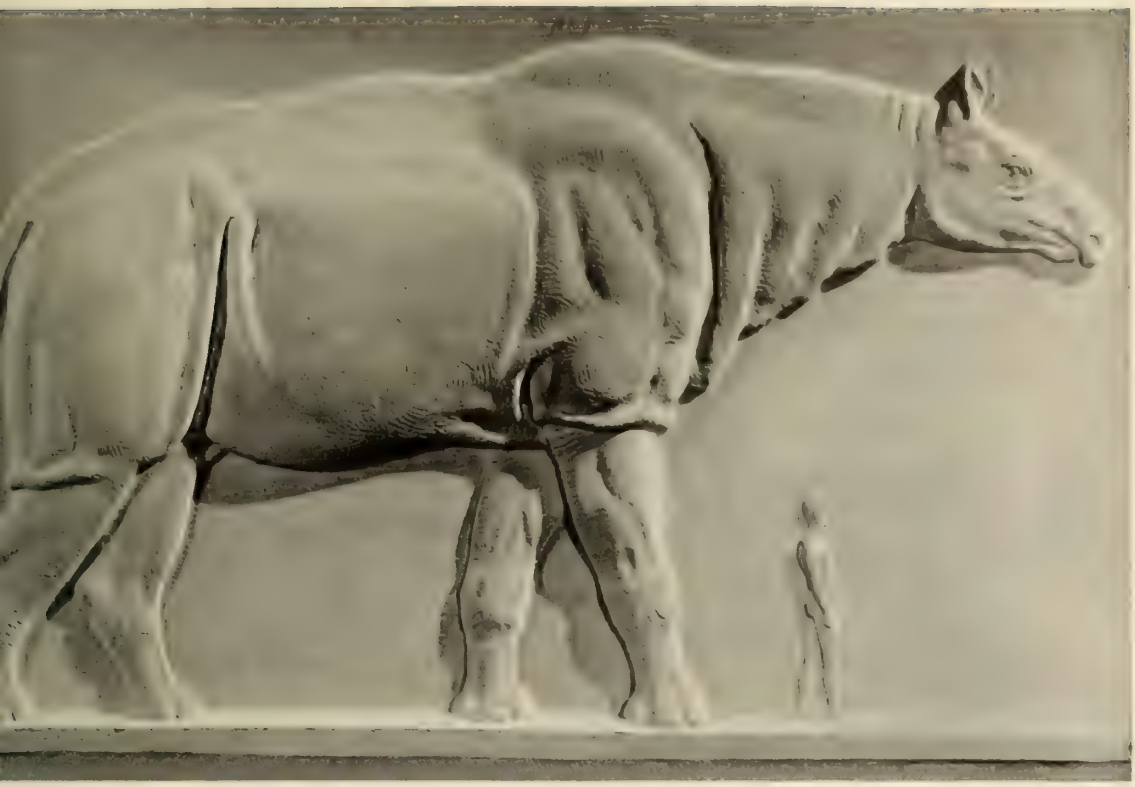
Two extraordinary armored dinosaurs are represented by parts of their skeletons. *Ankylosaurus,* which has been called "the most ponderous animated citadel the world has ever seen," was protected about its head and body by thick plates of bone, while the tail, instead of tapering to a point, ended in a great bony ball. Nearby is the fore part of *Palaeoscincus,* whose sides bristled with huge bony spines and whose back was protected by bony plates.

On the right and left of the entrance are two lightly but powerfully built flesh-eating dinosaurs known as *Gorgosaurus.* They were doubtless swift and fierce and preyed upon other dinosaurs.

Near these are examples of a small dinosaur whose general appearance suggests an ostrich, but with a long tail. On account of this resemblance it is known as *Struthiomimus.* This bird-like appearance, however, is purely superficial as it

DINOSAURS AND THEIR EGGS *(Protoceratops andrewsi)*. From the western Gobi





A RESTORATION OF BALUCHITHERIUM, a gigantic fossil rhinoceros 34 feet in length

is not at all related to the ostrich. Nevertheless, primitive birds originated from light-boned pre-dinosaurs of a far earlier epoch (Triassic). Some examples of fossil birds are shown in the farther right-hand corner of the hall, including the giant long-legged *Diatryma* with its powerful beak, and the ancient swimming water bird, *Hesperornis*. In a neighboring case are casts of the famous *Archæopteryx*. This creature was actually transitional between reptiles and birds, having the skeletal characteristics, clawed fore-limb, and tapering tail of the former and the beak-shaped jaws and feathered covering of the latter. On the wall opposite are fossils and drawings of the great flying reptile, *Pteranodon*. A thin fold of skin extending from the elongated fourth finger to the outer edge of the feet enabled *Pteranodon* to fly through the air like a huge bat or vulture.

Hall of Mongolian Vertebrates

(Index Plan, p. 19, Floor IV, Hall 5)

Here are exhibits of specimens obtained by the Central Asiatic Expeditions. Among them are the famous dinosaur eggs and skulls and skeletons of the dinosaur, *Protoceratops,* that laid them. Here also is the skull of *Andrewsarchus,* the largest of carnivorous land-mammals; the shovel-tusk mastodon; and the skull and feet of *Baluchitherium,* an ancient relative of the rhinoceros, of titanic proportions. On the wall is a life-size model in low relief of this largest of all land-mammals.

Osborn Hall of the Age of Mammals

(Index Plan, p. 19, Floor IV, Hall 3)

This hall includes fossil remains of mammals of the Tertiary Period. To the

left as one enters from the Hall of Mongolian Vertebrates, is a magnificent series of titanotheres, hoofed mammals related to the horses and rhinoceroses. This group has long been extinct but it embraces a remarkable series of evolutionary stages from creatures not much larger than a dog, up to great towering bulky animals with huge heads terminating in flat shovel-like horns of tremendous weight.

Opposite the titanotheres are the remains of condylarths and amblypods, very ancient hoofed mammals with no close relatives in the modern world. The most striking of these is the skeleton of *Uintatherium,* a six-horned amblypod with a tiny brain. This race became extinct early in the Age of Mammals.

Beyond the amblypods are cases devoted principally to the smaller fossil mammals. Although fragmentary, these are among the rarest and most interesting of fossils. The fossil primates (lemurs, monkeys, etc.) include unique specimens known throughout the world because of the light they cast on the earliest stages in the origin of man. Rodents (squirrels, rabbits, and their kin), insectivores (moles, hedgehogs, etc.), and marsupials (opossums, kangaroos, and their allies) are also typically represented here.

The ancestry of dogs, cats, and other living flesh-eating mammals and the various sorts of extinct carnivores including rare creodonts is shown near the middle of the hall on the right.

Fossil rhinoceroses are shown near the center of the hall on the left. A fine series of skeletons illustrates the diverse types of American rhinoceroses, and a synoptic series shows the evolution of this group of mammals. The large block in the central aisle is from Agate, Nebraska, and contains heaped-up bones, chiefly of the double-horned rhinoceros, *Diceratherium,* still in the original rock, as found. There are twenty-one skulls and innumerable other bones in this single block, giving a graphic conception of the enormous numbers of prehistoric animals that once roamed over our West. Near this, in the center of the hall, is the skeleton of *Moropus,* a most extraordinary mammal of bizarre proportions and equipped with great claws. Nevertheless, it belongs among the hoofed mammals and is related to the horses and rhinoceroses.

TITANOTHERES. These long-extinct relatives of the horses and rhinoceroses began as small animals about the size of a small fox. The last of the titanotheres such as *Brontotherium,* on the left, were gigantic beasts with horns on the front of the skull





A GROUP OF MIOCENE CAMEL SKELETONS *(Stenomylus)*. Some of these are mounted in characteristic attitudes as if they were alive, others are lying on the rock matrix as their remains were actually found by a Museum expedition. These camels inhabited America at the beginning of the Miocene Period

Also on the right side of the hall are specimens illustrating the evolution of the even-toed mammals, or Artiodactyls. Here are found the pigs and their relatives, the peculiar extinct oreodonts, the camels, deer, giraffes, and cattle.

The group of small camels in the central aisle forms a striking display. The graceful little animals, *Stenomylus,* lived in Nebraska during the middle of the Age of Mammals. Four skeletons are shown exactly as they were found in the rock, and five others have been mounted in various living poses.

Among the other cloven-hoofed mammals, the so-called giant pigs or entelodonts and the oreodonts are noteworthy. The latter, a totally extinct group somewhat pig-like in appearance but with teeth more like those of sheep, are strikingly represented by three complete skeletons huddled together, still intact in the rock just as death overtook them millions of years ago.

On this side of the hall are found skeletons of two extinct sea cows, one from Europe, the other from Florida. In addition at the end of the hall is a special exhibit of extinct proboscideans, mammals related to the modern elephants.

One of the most outstanding exhibits is the series of skeletons in the last alcove on the left showing the evolution of the horse. This display presents the story



MAMMALS OF THE LOWER PLIOCENE PERIOD IN NORTHERN NEBRASKA. During this period short-limbed rhinoceroses lived with ancient camels and single-toed horses of small size. Murals by Charles R. Knight

from the little Eocene mammal, *Eohippus,* through intermediate stages to the Pleistocene and modern horses, *Equus.* (See Guide Leaflet No. 36, *The Evolution of the Horse.*) As shown by skeletons of horse and man in another hall, the single toe of the horse corresponds to the middle finger or toe of man, and the same correspondence is seen in each of the other leg and arm bones. In the modern horse, all but the middle finger and toe have disappeared or have been reduced to "splint bones," but the remote ancestor of the horse had five toes.

The Horse Under Domestication

(Index Plan, p. 19, Floor IV, Hall 2a)

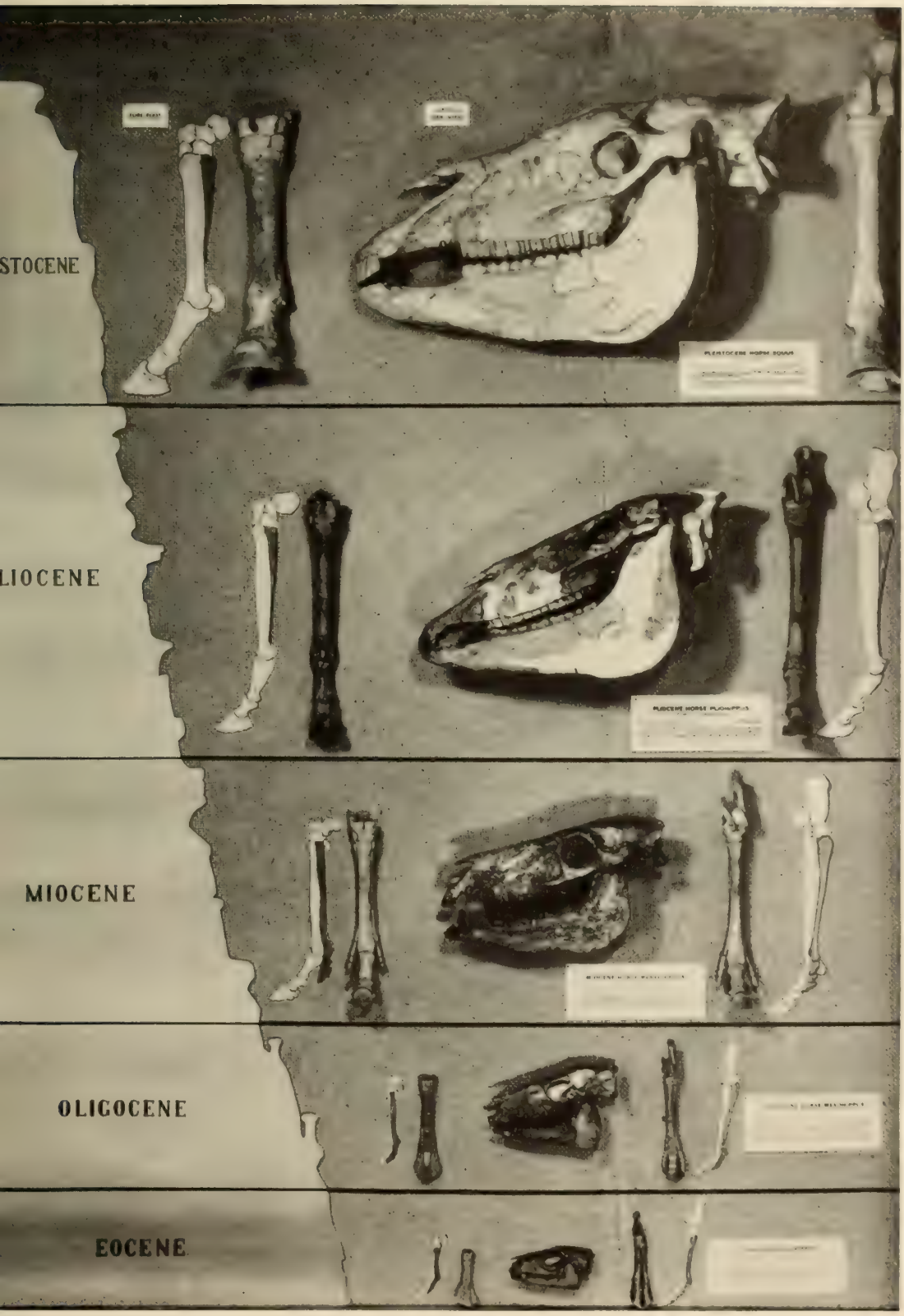
This hall is devoted to exhibits illustrating the great modifications that man has brought about by selection in adapting the horse to his various needs.

Under his management speed has been increased in the race horse, weight and strength in the draft horse, while the Shetland Pony has been reduced to a diminutive size. The modifications in the skeleton that have accompanied these changes are well shown in the notable series of beautiful skeletons mounted by S. H. Chubb.

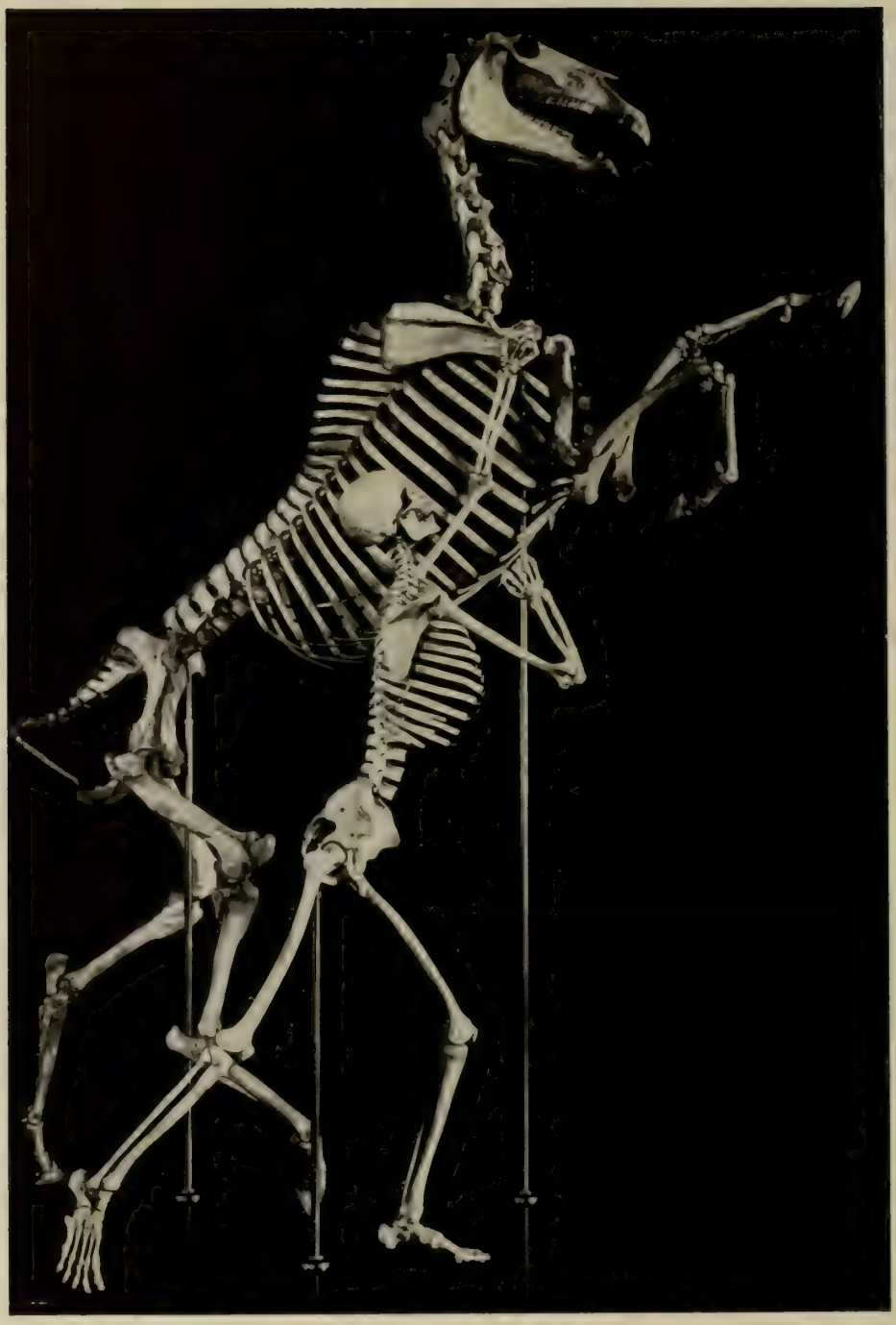
The similarity in structure (homology) of the skeletons of horse and man is brought out in the exhibit of a rearing horse, controlled by man. It is interesting to note that both skeletons have the same principal parts, in spite of many conspicuous differences. In the horse the long upper and lower jaws, together with the high-crowned grinding teeth, form a very efficient mechanism for cropping and grinding the tough stems and hard kernels of grasses and similar vege-

MAMMALS OF THE UPPER PLIOCENE PERIOD IN NORTHERN TEXAS. The single-toed horses *(Plesippus)* were of larger size than those above, while the camels were more nearly like those of modern types. *Glyptotherium,* a gigantic armadillo-like animal, is shown in the lower left





EVOLUTION OF THE HORSE shown by skull and foot bones. (See text)



SKELETONS OF HORSE AND MAN COMPARED

tation, whereas the short upper and lower jaws and low-crowned cheek teeth of man are adapted for a mixed diet. Moreover, the horse's long jaws enable him to reach his food, which is normally on or near the ground, while the short jaws of man have the food brought up to them by the hands.

The bony cranium or braincase of the horse is much smaller in proportion to the weight of the body than is the braincase of man, which is greatly enlarged by the enormous growth of the human brain. The bony hands of the remote ancestors of the horse have become greatly modified during long ages of specialization for swift running. Thus each "hand" of the modern horse has but one finger, is very long and slender, and terminates in a thick horny hoof corresponding to the nail on the middle finger of the hand of man. Likewise the bone beneath the hoof corresponds to the last bone of the middle finger of the human hand. The visitor may enjoy making similar comparisons for himself: for example, where is the so-called "knee" of the foreleg of the horse and to what does it correspond in man? (Answer: the wrist.) Where is the true knee in the hind leg of the horse and where is its heel bone? What has become of the fibula or outer bone of the lower leg in the horse? Where is the "cannon bone" in the foot of the horse and to what does it correspond in man?

But why do the skeletons of horse and man have so many parts that correspond to each other? There can be no reasonable doubt that the remote common ancestors of horse and man were small mammals with five toes on all four feet. The structural differences have arisen as the result of gradually increasing differences in habits, the horse finally becoming highly specialized for running and leaping on all fours, while man uses his fore limbs as arms and hands and balances his body on his hind legs.

Osborn Hall of the Age of Man

(Index Plan, p. 19, Floor IV, Hall 2)

This hall is devoted to early man and his contemporaries, the mammoths and mastodons, and the giant ground sloths of South America. The collection displayed through the center of the hall illustrates what is known of the early history of our own race as shown by the remains of early man and the implements he used. As fossil remains of man are rare and usually very fragmentary, these are represented mainly by casts, but they include examples of all the more perfect and noteworthy specimens that have been found, from the Neanderthal and Gibraltar, to the Piltdown and Talgai. (See Guide Leaflet No. 52, *The Hall of the Age of Man.*) These are illustrated and further described on pages 125-126.

In the surrounding cases are some of the principal skeletons and skulls of animals mostly of Pleistocene Age, known to have been associated with man especially in North and South America. Skeletons and skulls on the right side of the hall show the evolution of the Proboscidea. They fall naturally into two groups; first, the mastodons; and secondly, the mammoths and elephants. In the former division, beginning near the entrance of the hall, are the most primitive mastodons, with two upper and two lower tusks, and a very short proboscis. The succeeding cases show the gradual reduction of the number of teeth and the shortening of the front part of the skull for the accommodation of the longer proboscis found in all of the later stages of mastodons and mammoths.

On the left is a group illustrating the famous asphalt trap of Rancho la Brea at Los Angeles, California, and fossils from South America, the most striking of which is the group of giant ground sloths. There are also good examples of glyptodonts, gigantic relatives of the armadillo. Among other strange extinct animals are the camel-like *Macrauchenia*, and the rhinoceros-like *Toxodon*. These evolved in South America during the Age of Mammals when it was an island continent as Australia is today. Here, too, are the fossils of other mammals which evolved in South America during its period of isolation from the northern part of the Western Hemisphere.

On the walls are mural decorations painted by Charles R. Knight showing the typical groups of Pleistocene animals of North and South America and Europe that were associated with early man.



MOUNTED SKELETONS OF EXTINCT ANIMALS OF SOUTH AMERICA



PREHISTORIC saber-tooth tiger, dire wolf, and giant sloth, caught in the tar pools of La Brea, California. *(Above)* as mounted skeletons; *(below)* as conceived by the artist, Charles R. Knight



(above)
OLLY
MMOTH
he River
m m e ,
ce, dur-
g t h e
th Gla-
Period.



(left)
SKELETON
OF THE
JEFFER-
SONIAN
MAMMOTH
from Indiana

THE WOOL-
LY RHI-
NOCEROS
DURING A
GLACIAL
WINTER IN
NORTHERN
FRANCE.
The Murals
by Charles
R. Knight.



MODEL OF RHODODENDRON in the Forestry and Conservation Hall. Many of the trees in this Hall are accompanied by models of leaves, flowers, or fruit

FORESTRY AND CONSERVATION

(Index Plan, p. 16, Floor I, Hall 3)

Jesup Forestry Hall. The Forestry and Conservation Hall contains a nearly complete collection of the native trees north of Mexico presented by Morris K. Jesup. On the right is a bronze tablet by J. E. Fraser, the gift of J. J. Clancy, depicting Mr. Jesup as he walked in his favorite wood at Lenox, Massachusetts. In front is a bust of Charles Sprague Sargent, under whose direction the collection was brought together. At the farther end is a bust of John Muir, by Malvina Hoffman, presented by Mrs. E. H. Harriman.

To the left is a section of one of the Big Trees of California, sixteen feet in diameter and 1341 years old. (See Guide Leaflet No. 42.) It began its growth in the year 550, so that it was nearly a thousand years old before America was discovered. The label, illustrating the conclusions reached by Ellsworth Huntington as the result of long study, shows how the climate of the past is recorded by the trees and how great historical events are related to great changes in climate.

In the center of the hall near the entrance from the 77th Street Foyer is a splendid life-size model in wax of a magnolia blossom belonging to the species *Magnolia macrophylla,* surrounded by its long tapering leaves.

In the last alcove to the right is the Menken Collection of Glass Flowers, representing many of the common species of American flowers. They are modeled skillfully in glass, with their colors faithfully copied from nature.

In the center of the hall (Case D) will

be found a dissolving diorama, the first of a series on forest conservation. The first scene represents a forest area of Colorado White Pine in Idaho and shows the early glow of a forest fire in the distance. This dissolves into a scene of the same area after the fire, showing the burned trees, destroyed surface coverage, and general desolation.

The other specimens in the hall show cross, longitudinal, and oblique sections of the wood of North American forest trees, finished and unfinished. The labels adjacent give the distribution of the species, the characteristics of the wood, and its economic uses. The trees are grouped by families, and the location of each family will be found on the floor plans in the first case on either side of the hall. The reproductions of the flowers, leaves and fruits are made in the Museum laboratories.



A DISSOLVING-VIEW EXHIBIT in the Forestry and Conservation Hall. The disastrous effects of a forest fire are depicted when the three-dimensional scene above fades into the one below.



The Darwin Hall of the Evolution of Life

(Index Plan, p. 16, Floor I, Hall 5)

This hall is devoted chiefly to invertebrates and exhibits illustrating biological principles, especially those concerned with the evolution of life. It is, therefore, dedicated to Charles Darwin. Facing the entrance is a bronze bust of Darwin by William Couper, presented by the New York Academy of Sciences on the occasion of the Darwin centenary in 1909.

The Tree of Life

In the first upright case at the left is a Family Tree of the Animal Kingdom. Each class of animals is represented by a color sketch, and the branches show the relationships of the various classes and indicate the evolution of each group from the parent stem.

Synoptic Series

The exhibits in the succeeding upright cases comprise examples of the various groups or orders included in the Classes shown on the Family Tree. Passing around the hall from left to right, the progress of evolution is illustrated from the lowest forms, the Protozoa, to the highest, the Primates, which include man.

Alcove 1, Protozoa. This alcove contains the lowest forms of animal life. All are single-celled individuals. Some are abundant in swamps and stagnant water, others are found in the sea. These exhibits are mainly models, some of which represent Protozoa enlarged more than a thousand diameters.

Alcove 2, Sponges. Sponges are principally of three kinds — distinguished from each other by their skeletons of lime, silica (i. e., flint) and of horny fiber. The sponges of commerce belong to the latter class. In the dry specimens exhibited, the skeleton only can be seen, the living tissue having been removed. Sponges range in size from the tiny *Grantia* of the New England coast to the gigantic "Neptune's goblets" of the eastern seas.

Alcove 3, Polyps. Here are shown coral animals and their relatives: among them, colonial hydroids; jellyfishes, brilliantly colored sea anemones, sea fans and sea plumes; the stony corals, and the precious coral.

Alcove 4, Flatworms. The best known species include the tapeworms, whose development and structure are shown by models in the left-hand alcove case. The less familiar free-living flatworms, which inhabit both salt and fresh water, are represented by enlarged models.

Alcove 5, Roundworms. The roundworms are parasitic, since they live in the digestive canal of mammals. The most familiar is the common stomach worm, *Ascaris,* of which an enlarged model shows the internal structure.

Alcove 6, Rotifiers. The minute wheel animalcules, otherwise called rotifers, comprise many exquisite and grotesque forms, some of which construct tubes of a gelatinous substance, sand-grains, etc. A few species are parasitic, but most of them live a free, active life. They are found mainly in fresh water. See group in window showing rotifers in their natural environment and the comparative series of enlarged models of typical rotifers in the case to the left.

Alcove 7, Sea-Mats and Lamp-Shells. The sea-mats are minute, colonial animals of plant-like growth, often occurring as encrustations on shells and seaweed. A few species also occur in fresh water. The lamp-shells shown in this alcove superficially resemble clams, but by structure are more closely related to the sea-mats.

Alcove 8, Sea-Stars and Their Relatives. Here are shown sea-stars, brittle stars, sea-urchins, sea-cucumbers and sea-lilies. The sea-star is the pest of the oyster beds, where it feeds on oysters and destroys them in large numbers.

Alcove 9, Annulates. As typified by the familiar earthworm, these are worms whose bodies are made up of rings or segments. They are inhabitants of both fresh and salt water, many kinds living in the mud and sand of the shore while others bore into wood and shells. Their



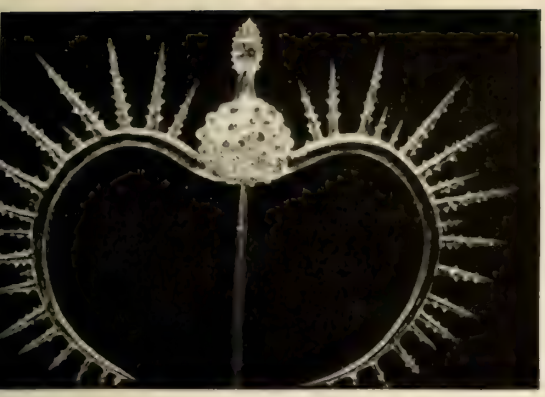
A CORNER OF THE NAHANT TIDE POOL GROUP. On the rocky northern New England Coast are numerous basin-like crevices in the cliffs. At high tide, many of these are totally submerged, but as the water recedes they are left as stranded pools richly populated with marine animals and plants. In the Tide Pool Group in the Darwin Hall, sea-anemones and hydroids are disclosed among the rockweed, sea-lettuce and kelp



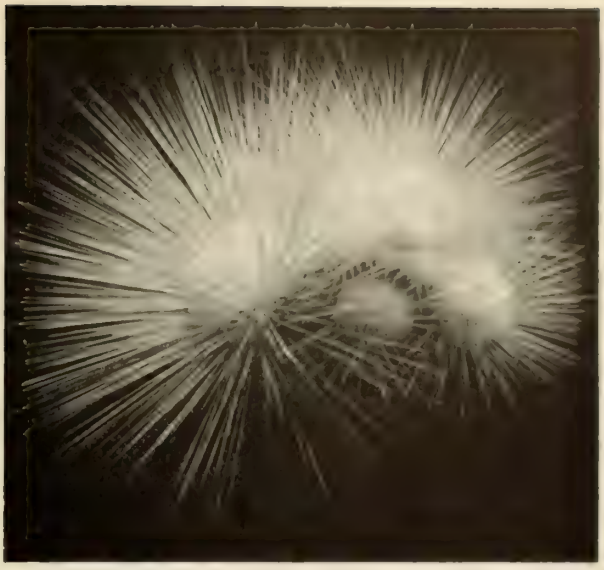
A DETAIL FROM THE ROTIFER GROUP. A world of microscopic life magnified a million times shown in the Darwin Hall



(Left) The curious HORSE SHOE CRAB is a "living fossil" with ancestors dating back 700,000,000 years. A detail from the Sound Bottom Group



GLASS MODEL OF A TYPICAL RADIOLARIAN. These tiny floating marine creatures make glassy shells of intricate patterns and, when they die, sink to the sea-bottom to form radiolarian ooze, a flinty sand used for polishing precious stones



MODEL OF A ROCK-FORMING PROTOZOAN *(Globigerina)*. The microscopic creature shown above at the right builds tiny shells from lime dissolved in sea water. These become compacted into limestone layers on the sea-bottom. The Chalk Cliffs of Dover are composed of elevated masses of this rock



ENLARGED MODEL OF THE PLUMED WORM *(Diopatra)*



GLASS MODEL OF THE PORTUGUESE MAN-OF-WAR IN THE DARWIN HALL

body structures are often very beautiful and interesting examples of ingenious adaptation.

Alcove 10, Arthropods. Here are included the familiar crabs, lobsters, myriapods, insects, spiders and their relatives. The number of existing species in this group is greater than that of all the rest of the animal kingdom.

On the wall are the two largest lobsters ever taken. They weighed when alive thirty-one and thirty-four pounds, respectively. The largest of the arthropods is the giant crab of Japan, which, like that placed on the wall, may have a spread of about ten feet.

A series of models of insect heads, carefully wrought in wax and glass, shows, greatly enlarged, their comparative anatomy.

Alcove 11, Mollusks. The mollusks are next to the arthropods in the diversity and vast number of forms which they embrace, including marine, fresh-water and land animals. All mollusks have soft bodies, but nearly all secrete a shell which is often of pearly material (mother-of-pearl). Well-known examples of this group are the common clam and oyster. Enlarged models show the anatomy of these species. The main collection of mollusks is shown in the Hall of Ocean Life.

Alcove 12, Chordates, including Vertebrates. Vertebrates include the largest, most powerful and most intelligent of animals, the group culminating in man. Among the ancestral forms suggesting transitional stages from invertebrates are the "acorn-worm," *Dolichoglossus;* the Sea-squirts, or Ascidians; and the Lancelet, *Amphioxus.* Enlarged models showing, carefully dissected, their comparative internal anatomy are exhibited in the case to the left. Various species of Ascidians with their associated environment are shown among the animals on the wharf-piles in the window group. Other models in a case toward the front of the hall show the development of the egg of certain typical vertebrates.

Window Groups

In several of the alcove windows are habitat groups of invertebrates illustrating the natural history of the commoner and more typical forms.

Marine Worm Group. In the Annulate Alcove is shown the Marine Worm Group, reproducing these animals with their associates in their natural surroundings, as seen in the harbor of Woods Hole, Massachusetts.

Shore Mollusk Group. In the Mollusk Alcove is shown the natural history of a sand-spit at Cold Spring Harbor, Long Island, including some of the shore mollusks and their associates.

Wharf Pile Group. This shows the submerged piles of an old wharf at Vineyard Haven, Massachusetts, covered with flower-like colonies of sea-anemones, hydroids and other stationary animals.

Rock Tide-Pool Group. In the farther left-hand corner of the hall, a window group shows the animals and plants of a rock tide-pool, the "Agassiz Cave," at Nahant, Massachusetts. The falling tide has left a pool in a rocky basin, sheltered within which is a community of sea-anemones, sea-stars, and other invertebrates.

Sound Bottom Group. In the Arthropod Alcove, a group shows the struggle for existence among Crustacea on the sandy bottom of Vineyard Sound, Massachusetts. Here is a den of lobsters in a crevice beneath the seaweed-covered granite boulders forming the reef known as the Devil's Bridge.

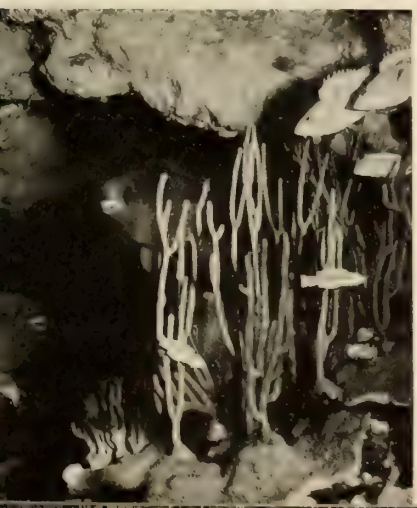
Bryozoa Group. Another group represents two square inches of sea bottom as though enlarged under a microscope to an area five feet square. The front of the case is built to represent a huge magnifying glass, through which the visitor sees marine plants magnified to tree-like proportions, encrusted with colonies of Bryozoa or "sea-mats," composed of thousands of individuals, each of which builds a shell of vase-like form. Associated animals, such as the flower-like, tube-building worms and sea spiders, are enlarged to grotesque proportions.

Rotifer Group. A companion exhibit represents a cubic half-inch of pond bottom enlarged one hundred diameters or cubically a million times, transforming a minute area into a towering aquatic forest peopled by rotifers and myriads of other strange creatures ordinarily invisible to the naked eye.

A PORTION OF THE BAHAMAN CORAL REEF GROUP IN THE HALL OF OCEAN LIFE. This group, the largest in the Museum, contains more than forty tons of coral from Andros Island in the Bahamas and faithfully depicts a portion of the magnificent barrier reef as it appears from the sea bottom

Right) BLACK ANGEL FISHES swim n stately fashion among the corals

Below) BLUE PARROT FISH peer out from a mysterious cavern in the heart of the reef







SPINDLE SHELL (*Fusinus*). These graceful shells are characterized by the long twisted spire and slender tapering canal terminating the body whorl

The Coral Reef Group

(Index Plan, p. 16, Floor I, Hall 10)

As you enter the Hall of Ocean Life on the gallery level the **Bahaman Coral Reef Group** is seen at the farther end. Its proscenium arch rises from the main floor, passes through the gallery, and frames the upper part of the group in a half-circle 35 feet high.

The portion of the group above the gallery presents a vista of coral island, quiet lagoon, and tropical sky. On the distant horizon the low-lying Bahaman Island of Andros is visible, soft with its fringe of coconut palms. Here the finest coral barrier reef in the West Indies parallels the shore. The small island in the foreground is Goat Cay, just back of the barrier reef.

The section of the group below the gallery obviously depicts the coral forest as seen from the bottom of the sea. On either side, staircases permit visitors to descend from the gallery, to find themselves standing on the ocean floor, gazing into the heart of a magnificent coral forest. The branching trees of elkhorn coral (*Acropora palmata*) rise to the water surface sixteen feet above. A rocky arch at the right leads into the Cave of the Blue Parrot-fishes, inhabited by three of these magnificent creatures.

Between the rocky wall and the spreading tangle of the coral forest a vista opens out into a clearing where a school of black-angel fishes swims by in the distance. In the foreground are squirrelfishes, striped and gray grunts, blueheads, slippery dicks, and spotted hinds. Above, a school of yellow-tails swims around the coral cliff, and houndfishes dart about, alarmed by the approach of a barracuda visible just beneath the water-surface at the upper left. Rock beauties, butterfly fishes, and blue angel-fishes swim among the sea fans, sea-bushes and sea-plumes; while a large rainbow parrot-fish, Nassau groupers, and a huge green moray lurk in the crevices and caverns under the coral. The latter is gay with encrusting and chimney sponges of scarlet, green, purple, yellow, and gray. To the left, queen triggerfishes, numerous butterfly fishes, and a grotesque trumpet fish swim above the great heads of brain coral, orb coral, and star coral.

Pearl Divers Group

(Index Plan, p. 16, Floor I, Hall 10)

This group represents a scene on the ocean floor within the enclosed lagoon of the coral atoll of Tongareva, or Penrhyn Island. This is a small ring-shaped island, eleven miles in diameter, situated in the South Pacific Ocean about 2,000 miles due south of Honolulu. In the central panel of the group, two Tongarevan

pearl divers are seen plunging down into a gorge in the heart of one of the magnificent coral reefs which form the island. They are engaged in gathering shells of Meleagrina, the "oyster" in which are found the precious pearls. They go about their work despite the dangers evidenced by the large shark swimming in the background, by the octopus lurking near the entrance of a near-by cave, and by the scarlet sixteen-rayed sea-star with its hundreds of poisonous sharp spines which is lying under the giant spiral mass of the acropore coral in the center of the group. As they work, fishes of every gaudy hue dart past them.

In the panel to the right, we look into a cavelike opening in the coral which has been pre-empted by the octopuses. One glides down from a ledge above the cave, another lurks in a shadowy crevice, while a third swims out through an

A DETAIL OF THE PEARL DIVERS GROUP. A coral fairyland of Tongareva Island, teeming with variegated undersea life, is the scene in which this native diver is shown searching for pearl shell.



arched tunnel, trailing its tentacular arms behind.

The panel on the left side of the group depicts the clifflike coral wall of the gorge, on which is grouped a colony of man-trap clams, *Tridacna*. The sinuous apertures of the shells are partially opened, revealing the gaily-colored mantle edges.

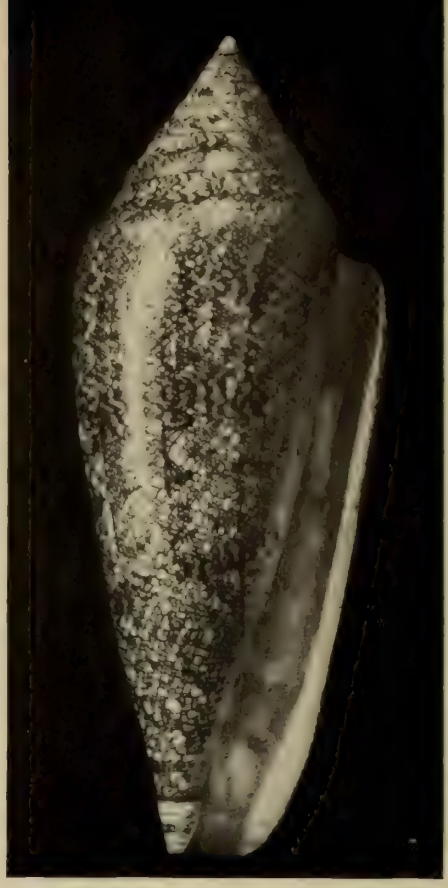
The group serves to emphasize the beauty of the delicate fronds and finely divided clusters of coral found in the Pacific reefs, as contrasted with the wierd branching species of the Atlantic coral faunas depicted in the adjacent Bahaman Coral Reef Group.

In cases near by are shown undersea paintings which were used in the creation of this realistic exhibit and other related ones.

Directly above the Pearl Diver Group is a mural by F. L. Jaques depicting the native divers in their outrigger canoes.

The corresponding position at the left of the Coral Reef Group is occupied by a mural showing Florida sponge boats and their diving crews.

Other exhibits in the Hall of Ocean Life are described on pages 116-120.



THE PEARLY OR CHAMBERED NAUTILUS *(Sectioned shell with animal in place)*. This remarkable creature belongs to a bygone age. It is the only surviving species of a long line of fossil forms reaching back 500,000,000 years or more

THE GLORY OF THE SEA *(Conus gloriamaris)*. This is the rarest and most romantic of shells. Only a dozen specimens are known, and none have been collected for more than a century. The Museum possesses two specimens



Gallery of Shells

(Index Plan, p. 16, Floor I, Hall 10, balcony)

Around the gallery of the Hall of Ocean Life is one of the largest and finest shell collections on display in any museum. Together with the study collections it comprises more than 760,000 catalogued specimens. It includes many shells of unusual beauty and rarity, as well as important private collections donated to the Museum.

The largest shell is that of the giant clam, *Tridacna,* weighing 579 pounds, exhibited in the small foyer as one enters from the Hall of Fishes. The largest mollusk known, however, is represented by the model of the Giant Squid *(Architeuthis princeps)* which is suspended above the balcony just inside the entrance. This species has been known to reach a length of over 50 feet.

The mollusks are classified in five main groups, as follows:

The **Amphineura** or Chitons and their relatives. These are the most primitive of living mollusks, the larger number of them having an oval, creeping body with a jointed shell of eight transverse plates. They have a certain serial repetition of body-parts and breathe by means of a double row of plume-like gills.

The **Gastropoda** or Snails. This is the most important group in number of species, distribution, and extent of diversification. They are the most ancient from the standpoint of fossil remains. The earliest shells resembled a "liberty cap," being cone-shaped with the shell uncoiled. Soon forms appeared with a one-sided roll. A little later the spirally twisted and usually right-handed shell was established, which has been generally characteristic ever since. The twist of the shell is reflected in the internal anatomy. In some gastropods the shell has become reduced, in others it has disappeared entirely.

The **Scaphopoda** or Tusk-Shells are relatively unimportant, comprising only a few species. They possess a shell shaped like an elephant's tusk open at both ends.

The **Pelecypoda** or Bivalves, including oysters, clams and their relatives, have the mantle divided into two halves, each of which secretes a shell. These, nearly equal in size, are hinged together. The foot is flattened vertically and extends down from the enclosed body-mass. It may be protruded from between the two shells for digging or swimming. Delicate, flattened and fine-meshed gill-flaps on either side furnish breathing organs and an arrangement for filtering out food-particles.

The **Cephalopoda** include the swiftly moving squids, cuttlefishes, and octopuses. This highly organized and specialized group is composed of predaceous species with efficient eyes and a peculiar method of propulsion. The Pearly Nautilus is the most ancient type.

The arrangement of the shells in the gallery is as follows: The Amphineura, Marine Gastropoda, and Scaphopoda are exhibited in the series of "A-cases" along the two sides of the gallery in the order of their families. The A-cases are numbered from 1 to 40.

The Pulmonates or Land Gastropoda are displayed in the tops of eight table-cases, of which four are at either end of the hall in the transverse galleries. They are also arranged by families.

The Pelecypods, or bivalves, and the Cephalopoda are in the "wall-cases" on either side-gallery, beneath the murals.

In the wall-cases on either side of the entrance are shells especially selected for their size and beauty, those to the right as one enters the hall, being from the Constable collection, and those to the left mainly from the Steward collection.

In the wall-case at the farther end of the gallery to the right of the Coral Reef Group is a series showing the commercial uses of shells and shells with unusual deformities. Continuing around the angle of the gallery is an exhibit illustrating the fisheries of fresh-water pearl shells and the pearl button industry.

In the shell laboratory to the right of the entrance foyer an attendant is ready to give information about shells and their location in the hall.

Invertebrates of New York State. A series of the principal invertebrates except insects found within the boundaries of New York State and its neighboring waters is exhibited in the corridor of the first floor of the Roosevelt Memorial to the right as one enters from the Fish Hall (Index Plan, p. 16, Floor I, Hall 12a).

STRIKING SPECIMENS FROM THE MOLLUSK COLLECTIONS

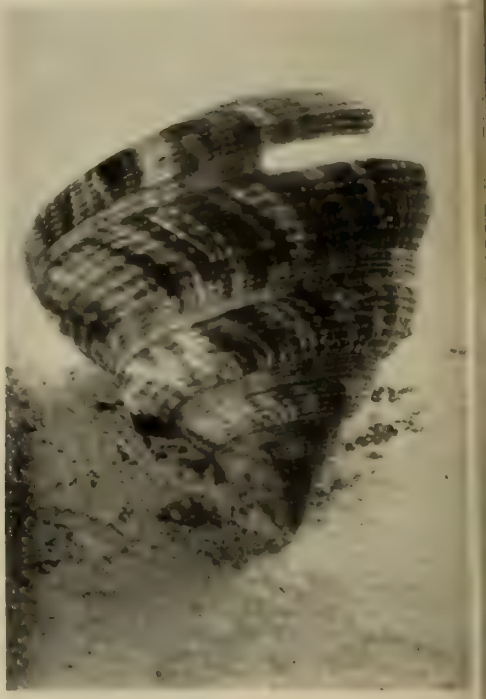
(Right) THE IMPERIAL HARP SHELL *(Harpa costata)*. The graceful shape of this shell suggests its name. Variegated with rich coloring, it is one of the most attractive of mollusks. It is distinguished by the close-set prominent ribs



(Right) THE RARE SLIT SHELL *(Pleurotomaria)*. A nearly extinct shell from deep water in the West Indies and near Japan, characterized by the broad slit extending partly around the outer whorl

(Below, right) NORTHERN SCALLOP *(Pecten islandicus)*: A form first discovered in Iceland

(Below, left) THE PAINTED THORNY OYSTER *(Spondylus pictorum)*. A beautifully tinted bivalve from Lower California. The spines are rose-red, orange or yellow









THE SEVENTEEN-YEAR CICADA *(Cicada septendecim* Linnaeus): from a Group in the Insect Hall. During May or June of a "locust year," the immature seventeen-year-old Cicadas emerge from underground and ascend tree-trunks. Within a few hours their skin splits along the back and the adult emerges. The female deposits her eggs in a succession of slits in the slender twigs. The song is produced only by the male

HALL OF INSECT LIFE

(Index Plan, p. 18, Floor III, Hall 5)

This interesting hall is virtually a textbook of Entomology. A series of "A-cases" surrounds the hall giving a vivid presentation of insect biology, including the relations between insects and vegetation, the importance of insects as carriers of disease, and general biological facts and theories as illustrated by insects. These cases are numbered to facilitate the work of teachers sending students here for information.

In the center of the hall is a circle of exhibits, some of which show mounted insects in life-like artificial surroundings. Among the habitat groups is a series illustrating the life-histories of common butterflies. The very beneficial Lady Beetles are shown next to the very injurious Japanese Beetle. Other groups are concerned with such tropical insects as the Leaf-cutting Ants. Exhibits of Mole Cricket and Dragonfly larva show the insects and environment magnified five diameters.

The walls of the hall are used for supplementary exhibits. One of these displays strikingly beautiful butterflies and moths from all parts of the world. Another demonstrates the wealth of insect life at our very doors. The commercial use of insect silk and the use spiders make of their silk occupy the wall on either side of the entrance to the Reptile Hall. On the wall around the corner to the right are shown some of the results of the research work of the entomological department, especially in the field of experimental biology.

The insects in the railing cases of the



A GATHERING OF MONARCH BUTTERFLIES. In early autumn the Monarch Butterfly, *Anosia plexippus*, assembles in great swarms in the northeastern United States. At nightfall, large numbers crowd the leaves and branches of trees or shrubs. These flocks move southward, much as birds migrate. Individual females come north the next spring and reestablish the northern population



MODEL OF A MOLE CRICKET (enlarged five diameters). An insect with fore-legs especially adapted for digging

adjoining Synoptic Hall of Mammals (Index Plan, p. 18, Floor III, Hall 3) are placed there temporarily.

The collections in general are arranged with special reference to the insects found near New York City. They are presented in two series:

General Series. This is arranged in a definite order which should be followed as indicated by numbers.

The topics treated are: Importance of Insects, Geological History and Relationships, Anatomy and Physiology, Development from Egg to Adult, Variation in Form and Color, Natural Selection, Inheritance, Collection and Identification, Habits, Enemies, Injuries to Man, Benefits to Man.

Butterflies of New York State. A striking exhibit of some of the butterflies found in the State of New York is installed in the corridor of the Roosevelt Memorial Building (Index Plan, p. 16, Floor I, Hall 12a) just to the left of the entrance from the Fish Hall on the first floor of the Museum.

MASSING OF LADY BEETLES ON MOUNTAIN TOP. From a group in the Insect Hall. With few exceptions Lady Beetles (Coccinellidae), both larvae and adults, eat either plant-lice or scale insects. The species of *Hippodamia* specialize on plant-lice. In the West, the adults often gather in large masses under rocks on the tops of mountains to pass the winter. Such a gathering near Boulder, Colorado, is shown here



BUMBLE-BEE POLLINATING APPLE BLOSSOMS. From an exhibit in the Insect Hall. A few insects cause a loss of about one-fifth of our fruit, but we should have little or no fruit were it not for other insects pollinating the blossoms

DRAGON FLY LARVA CATCHING A MOSQUITO LARVA by means of a curiously modified lower lip, which is jointed and has a pair of pincers at its tip. (Insect Hall)



HALL OF LIVING FISHES

(Index Plan, p. 16, Floor I, Hall 9)

On entering the Hall of Fishes from the Darwin Hall one faces a group of sharks, sweeping down upon a helpless logger-head turtle. The following sharks are represented in this group:

(1) **White Shark** or **Man-eater.** One of the largest sharks, growing to a length of 30 feet or more. This ferocious shark feeds on large fish and sea-turtles. It has been known to attack men and even small boats. Fortunately it is apparently rare everywhere and usually remains on the high seas.

(2) **Spot-fin Ground Shark** or **Shovel-nose.** May be recognized by its small second dorsal fin and very long tapering pectorals, in combination with a flattened shovel-like nose. It produces living young, feeds chiefly on fish and squid, and is harmless to man.

(3) **Southern Ground Shark.** Somewhat resembles the Tiger Shark but differs in its very blunt snout, stouter body, very large pectoral fins, and complete absence of spots. It inhabits coastal waters and feeds on fish, etc. It is common about wharves, where it picks up refuse, but is not dangerous to man.

(4) **Tiger Shark.** This fish sometimes reaches a length of 30 feet and is a very active, predaceous shark of the high seas. It has wide jaws and powerful sickle-shaped teeth, and it preys upon large sea turtles, other sharks, fish, and invertebrates. The tiger shark is much dreaded in the West Indies, but there

WHALE SHARK *(Rhineodon typus)*. This is the largest species of shark; represented here by an eighteen-foot specimen. Note the wide mouth rectangular jaw, light spots, and the parallel ridges extending toward the tail





THE SEA ROVERS. An undersea scene, showing a number of sharks attacking a sea turtle. In the lead is a twelve-foot Tiger Shark; on the left, a Hammerhead; and in the background, the White Shark or Man-Eater



MODEL OF THE MANTA OR DEVIL FISH *(Manta birostris)*. From a specimen taken off the west coast of Florida, measuring 17 feet across

is no authentic record of attacks on human beings.

(5) **Hammer-head Shark.** The strange flattened and widened face of this shark seems to serve as a bow-rudder, which is used in making very quick turns in pursuit of fish. It occasionally reaches a length of 12 feet.

(6) **Sand Shark.** This shark may be recognized by its combination of a delicate nose and unreduced second dorsal fin. The sand shark captures great numbers of small fish, which are its chief diet. There is no record that it attacks man.

The **Systematic Exhibit** includes a representative series of fishes, from the lowly "cartilage fishes," such as the sharks and rays, to the highest or most complexly constructed bony fishes. Noteworthy in this series are the mounted groups of "ganoids," including the sturgeons, spoonbills, bony gars, and bowfins, all of special scientific interest, since they are "living fossils," or descendants of the now extinct fishes of earlier geologic times. In the alcoves and wall cases on the right, the visitor will find many curious forms, such as the giant catfishes, the handsome rooster fish, the brilliant parrot wrasses, and butterfly fishes.

On the right side of the entrance to the inner enclosure is the **Biological Exhibit.** This considers the fish as a machine—its stream-line form, its main principles of construction, its locomotor machinery, and the mechanism of its jaws.

The **fish life of warm seas** is represented in the inner enclosure, including the giant Manta, or Devilfish, a small individual of the spotted Whale Shark, largest of fishes, and in the foreground a bit of sandy bottom with small species as it would appear about Bimini, Bahamas.



(Above) DEEP SEA ANGLERS. Note fishing rod with luminous tip

The model of a **Manta** or **Devilfish** *(Manta birostris)* was made from a specimen taken in 1915 near Captiva Islands, off the West Coast of Florida, by Russell J. Coles. It measures 17 feet across the out-stretched wings. Still larger specimens up to 22 feet wide are on record. The Manta, like other skates and rays, may be regarded as a "winged shark" in which the body has become depressed and the breast fins enlarged into "wings" which are the chief organs of locomotion.

The **Whale Shark** *(Rhineodon typus)* is an 18-foot specimen taken at Acapulco, Mexico, March 2, 1935. This species is the largest and most characteristically marked of living sharks. In 1935, 76 specimens had been recorded. Among these a measured specimen reached 45 feet in length, but there are reliable estimates of 60 to 70 feet. The markings form a striking pattern of vertical yellow bars separating vertical rows of yellow spots.

The **Deep Sea Fishes** form a special exhibit in an inner room. Here in the semi-darkness we view some of the hobgoblins of the ocean depths — many of them covered with jewels of phosphorescent light.

Fishes that live at great depths have to be able to endure enormous water pressure, low temperatures and total darkness. At one mile depth each square inch

(Below) VIPER FISH *(Chauliodus)* PURSUING BIGHEADS *(Melamphaes)*



of surface of a fish's body is under a pressure equal to about one ton. But the pressure is equal in all directions. It permeates the whole body of the fish inside and outside and evidently does not injure the most delicate tissues.

A small exhibit in the left-hand corner of the central darkened room tells of the remarkable life-history in which there is a striking transformation of the "stalk-eyed fish" into a "Gleaming-tailed Sea Dragon." This exhibit is based on the investigations and material of Dr. William Beebe in connection with deep sea fishes taken off Bermuda. He proved that the minute "stalk-eyed fish," which carries its eyes out at the ends of long stalks, really grows up into the "Gleaming-tailed Sea Dragon" (*Indiacanthus fasciola*), formerly supposed to be a different species.

The deep sea life is dependent ultimately upon the rain of food-bearing particles from the richer waters of the surface. The countless myriads of microscopic plants are absorbed by the microscopic animals and these by the billions of tiny copepods or shrimps, which in turn are devoured by the ravenous small fishes.

Many different kinds of deep sea fishes have the power of luminescence. In some fishes the surface of the body is studded with little glow lamps, each of which has a lens, a reflector and a gland for producing a substance called luciferin which emits a light when supplied with oxygen from the blood. The little shrimps and other creatures upon which the fish feeds are attracted toward the lights as the moth to the flame. The lights also enable fishes of the same kind to find each other and keep together in schools.

Big Game Fishes. At the end of the Fish Hall toward the Roosevelt Memorial is the exhibit of Big Game Fishes, including many of great size taken with rod and line chiefly by Zane Grey and Michael

(Thunnus thynnus). A
icent mounted tuna fish
the Exhibit of Game
Fishes

also called Tunny and Horse Mackerel. It occurs in both the Atlantic and Pacific, and huge individuals may reach a weight of over 1000 pounds.

The second specimen, a **Blue Marlin** (*Makaira nigricans ampla*), weighed 305 pounds and measured 10 feet in length. It was caught on rod and reel off Bimini, Bahamas, on July 2, 1934. A **Mako Shark** (*Isuropsis mako*), caught off Bimini, is shown making one of its characteristic leaps above water in search of food.

The tuna, the swordfish, the marlin, the sailfish, and the mackerel are all related, belonging to the same suborder of fishes, the Scombroidei, a group which attains the acme of speed and streamlined form. There is probably more confusion about the marlin than about any other large game fish. This is due, first, to its similarity to its close relatives, the swordfish, the sailfish, and the spearfish; secondly, to the number of different kinds of the marlin itself. The sail of the sailfish is much higher and longer than that of the marlin.

The swordfish in Case 42 shows a distinctly heavier body, longer and stouter sword, and shorter dorsal fin.

The spearfish (Case 42) is a somewhat intermediate form. Its long dorsal fin is considerably lower than that of the marlins.

On the wall in connection with the Big Game Fish exhibit may be found charts of the world record rod and reel catches.

Lerner. The huge ocean sunfish, caught by Mr. Grey with harpoon and gaff, weighed nearly a ton. A 74-pound channel bass, a 668-pound broadbill, and a 758-pound tuna look down from the walls.

The central feature of the **Sailfish Group** is the mounted skin of a fish caught off the rocky coast of Cape San Lucas, Lower California. It is shown in the act of leaping from the water in a desperate effort to shake the hook from its jaws.

Many other fishes well known to anglers and sportsmen, or greatly desired as closer acquaintances, hang in these cases, such as salmon, trout, perch, muskellunge, barracuda, yellowjack, bonefish, etc.

Three fine specimens of the fishes caught and presented by Michael Lerner are exhibited in special cases as if rising through the water. One is the mounted skin of a tuna (*Thunnus thynnus*) which measured 8 feet, 3 inches in length and weighed 555 pounds. It was caught on a rod and reel off Wedgeport, Nova Scotia. This is the common or **Bluefin Tuna.**

BLUE MARLIN
(Makaira nigricans ampla)

LIVING REPTILES

(Index Plan, p. 18, Floor III, Hall 9)

As one enters this hall from the Insect Hall, the attention is attracted by four floor exhibits containing some of the largest living reptiles—the alligator, king cobra, and Galápagos tortoise. A fine exhibit showing the largest living lizards is at the right of the entrance. These are the **Dragon Lizards of Komodo.** The species *Varanus komodoensis* occurs only on Komodo and adjacent small islands in the Dutch East Indies. The scene in the group is laid on Komodo. A large male dragon lizard has just killed a wild boar, while another dashes forth from a nearby jungle to dispute ownership with the first.

Dragon lizards feed on deer, wild boar and water buffalo, possibly also birds and their eggs. They readily attack each other and have been known to seize a wounded comrade.

The smaller lizard feeding on the boar is a female, the largest recorded individual of this sex. Few species of lizards show such a pronounced difference between the sexes.

Komodo Island is uninhabited except for a convict village of Malays. Dragon lizards quickly secrete themselves on the approach of man. They apparently use vision alone in detecting their enemies, as they fail to react to sounds, and, in fact, appear to be deaf.

The species is diurnal and hides away at night in large dens which it digs under the roots of trees or under rocks in the open.

Varanus komodoensis is a large monitor lizard of the family Varanidae. It is closely related to certain monitor lizards of Australia, particularly to giant forms known only as fossils from the Pleistocene of that continent. These fossil species seem to have reached fifteen or more feet in length. *Varanus komodoensis* does not exceed ten feet, but large specimens may weigh over two hundred fifty pounds. It is therefore very much heavier than any other living lizard.

THE DRAGON LIZARD OF KOMODO ISLAND *(Varanus komodoensis)*





RHINOCEROS IGUANA. This great Iguana from Santo Domingo is the most powerful lizard in the Americas. It is terrestrial, digging burrows in limestone

The specimens and materials for the dragon lizard exhibit were secured by an expedition of the American Museum under the leadership of Mr. William Douglas Burden.

Near by a large chart outlines the history of all the vertebrate animals, including the dragon lizards.

The central part of the hall is devoted to a large series of **floor groups,** showing various species of reptiles and amphibia in their natural environments. The cases on the right of the hall answer questions frequently asked, such as, "How do reptiles and amphibians feed?" "How do they protect themselves?" and "How do they breed?" also, "What is the economic value of reptiles and amphibians?"

The left wall of the hall contains a series of exhibits installed in sunken panels, in which some of the principles controlling the existence of reptiles and amphibians are illustrated. Among them are "Natural Selection, the Directing Principle of Evolution," "Isolation, a Major Factor in the Origin of Species," "Concealing Coloration and Form," and "Parallel Evolution."

Other exhibits are devoted to snake yarns, the structure of reptile skeletons, and to snake poisons and their treatment.

On the left of the hall, in an enclosed corridor, is a series of **habitat groups** portraying the home life of American reptiles and amphibians. The subjects of these in order from the front of the corridor are: — The Leatherback Tortoise; The Giant Salamander; The Bullfrog; A New England Marshland in Spring; West Indian Tree Frogs; Reptiles of the Southwest; Galápagos Iguana; Rhinoceros Iguana; Gila Monster; and the Florida Cypress Swamp. A few of these are described briefly.

The Rhinoceros Iguana Group illustrates the complete life history of a typical lizard. It inhabits the desert regions of Santo Domingo and is the most powerful lizard in the Americas.

It is a terrestrial animal, living in burrows which it digs through banks of limestone. The eggs are deposited during July in hills dug by the females in ad-



A CYPRESS SWAMP IN NORTHERN FLORIDA. Detail of a group in the Reptile Hall

joining sand flats. The young iguanas hatch out and frequently pull their egg shells with them to the surface. The Rhinoceros Iguana, like most other large iguanas, is a vegetarian, feeding on *Acacia* beans, *Saona* berries, and other products of the desert.

The group depicts the western shore of Lake Enriquilla, a dead sea in Santo Domingo, over 130 feet below the surface of the ocean.

The Reptiles and Amphibians of a Cypress Swamp. The primeval cypress swamps of northern Florida afford a home for the alligator, numerous turtles, lizards, snakes, and frogs. The large alligator on the left is a female guarding her nest (shown in cross section). Young turtles are hatching from eggs which have been hidden by the mother in the alligator's nest. The group is a reproduction of a Florida cypress swamp and river cove in September. It portrays the feeding habits of several snakes, the breeding habits of various turtles and toads, and many other reptiles and amphibians.

A New England Marshland in Spring. Toads and frogs come to the marshes and ponds in the spring to breed. The males call loudly to attract mates. The shrill peeping which arises from so many ponds of eastern United States is made by a diminutive tree frog, while the trill which resounds from many orchards and water lily ponds is the voice of the gray tree frogs. Each species of frog and toad has a distinctive voice. In calling, the throat of many species is blown out into a balloon-like sac and acts as a resonating

organ. The group represents a small section of a swamp in southern New England during early May.

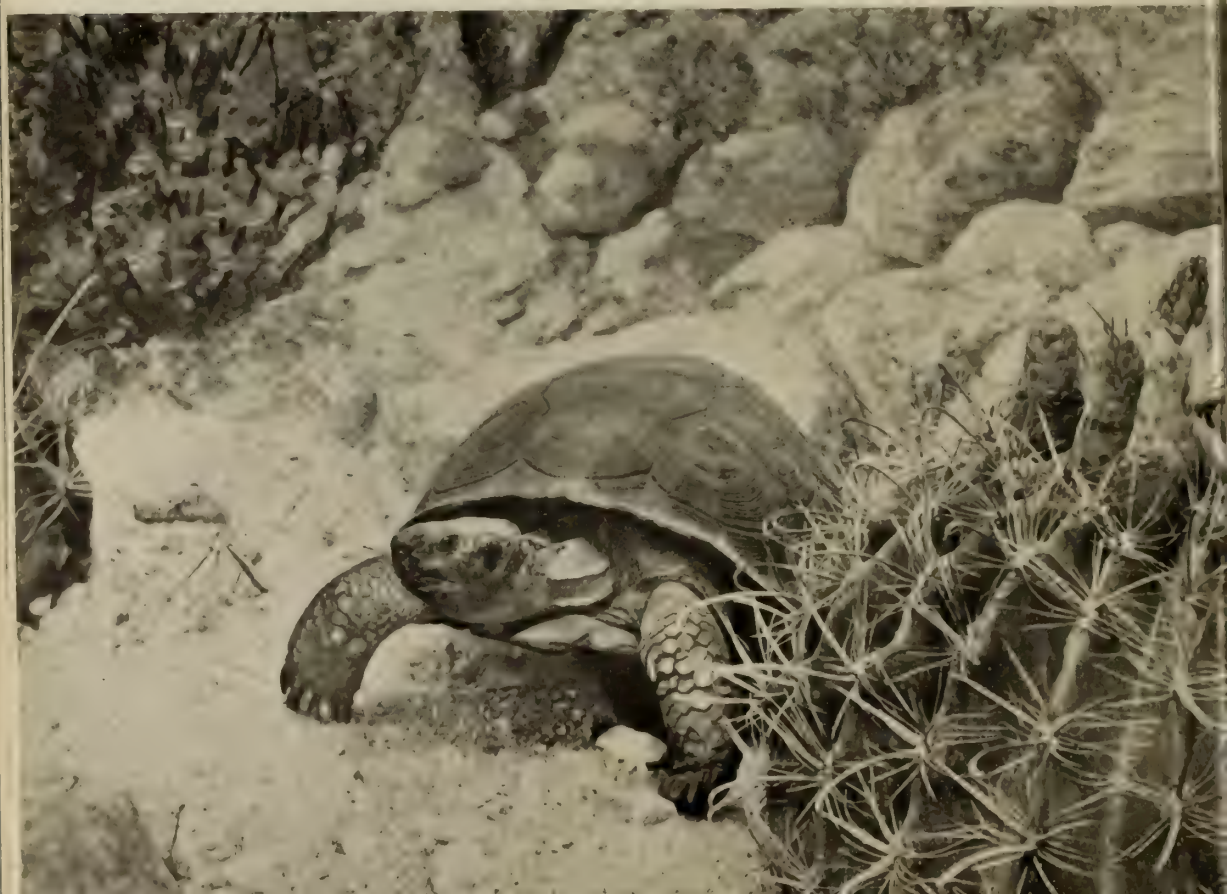
Gila Monsters. The Gila Monster is well known as the only poisonous lizard in the United States. In the group but one species, *Heloderma suspectum,* is shown. The only other poisonous lizard known, the Mexican Gila monster, *Heloderma horrendum*, is exhibited in a floor group in the adjacent main hall. The present group shows a small section of one of the canyons of the Santa Catalina Mountains, Arizona. The snake gliding over the rocks is the Sonoran Racer, *Masticophis bilineatus.* The desert tortoise, *Gopherus agassizii,* illustrated below, is seeking a hiding place for the night.

Amphibia and Reptiles of New York State. An exhibit showing the species found within the State of New York may be seen in the corridor of the Roosevelt Memorial on the first floor. (Index Plan, p. 16, Floor I, Hall 12a).



DETAIL OF A GROUP SHOWING THE AMPHIBIANS OF A NEW ENGLAND MARSHLAND IN EARLY SPRING

DESERT TORTOISE *(Gopherus agassizii).* A detail from the "Gila Monster Group," depicting the reptilian fauna of one of the Arizona canyons



THE WHITNEY WING

(Index Plan, pp. 16-19, Floors I-IV, Hall 19)

The Whitney Wing of the Museum, newest section of our structure, was a joint gift of the late Harry Payne Whitney and the City of New York. It is wholly occupied by the Museum's Department of Birds. Three of its eight floors are devoted completely or in part to public exhibits.

The main entrance of this wing leads into Whitney Memorial Hall from the New York State Theodore Roosevelt Memorial. The display represents bird life on islands in the Pacific Ocean, covering an expanse from the Hawaiian Islands southward beyond New Zealand and from the Galápagos Archipelago and small islets off the coast of Peru westward to the Australian barrier reef and New Guinea. Foyers at the ends of the hall contain maps and mural texts which describe both purpose and plan of the exhibits. Near the ends of the main hall are bronze busts of the late Messrs. William C. Whitney and Harry Payne Whitney, father and son, to whom the building and its contents are dedicated.

Whitney Memorial Hall

(Index Plan, p. 17, Floor II, Hall 19)

The design of Whitney Memorial Hall is intended to give Museum visitors the illusion that they are standing in the middle of the Pacific Ocean and viewing scenes in every direction throughout hundreds or even thousands of miles. In other words, the hall represents the Pacific itself, reduced to extremely small compass. A common horizon crosses the background of all 18 habitat groups, and from these the sky appears to rise behind the fronts of the cases and to be continuous with the blue dome that forms the ceiling of the hall. Suspended by invisible wires in this vault are examples of oceanic birds which inhabit the Pacific from the tropical environment depicted near the northern end of the hall to the edge of the Antarctic toward the south end. It is through the latter that the visitor approaches from the Roosevelt Memorial building.

At the present time only about three-fourths of the exhibits are completed. In addition to the dome and the decorations in the two foyers, nine groups on the right-hand side of the hall and four on the left are on display. These are as follows:

Ship-Followers. The point of view is from the deck of an old-fashioned sailing vessel in the open ocean south and east of New Zealand, in the zone of the westerly winds. In the background is the Whitney South Sea Expedition schooner, the "France," which served the American Museum during ten years in Polynesia. The expedition collected most of the specimens used throughout this hall.

Pelagic birds shown in the exhibit comprise a variety of albatrosses and petrels, especially characteristic of the higher southern latitudes.

Samoa. A view from the hills of the island of Savaii toward the ocean. The site is at the point where forest meets more open slopes. The birds include those of both woodland and grassland, such as fruit pigeons, ducks, members of the parrot family and many smaller forms. Especially noteworthy is the tooth-billed pigeon *(Didunculus)*, a very peculiar member of the pigeon family, confined entirely to a few islands of the Samoan group.

Tuamotu. The island of Hao, an atoll, with the coral-grown lagoon at the left and the surf of the open ocean on the right. In the distant background can be seen tree- and shrub-covered segments of the island ring. Among the coconut palms and other typical beach vegetation of a coral island are man-o'-war birds, boobies, a nesting red-tailed tropic-bird, several terns, including the white fairy tern which lays its egg on rough bark or in the crotch of a bush, and also a number of shore birds of both migratory and resident species. The example of the latter is the rare or nearly extinct Polynesian



PERUVIAN GUANO GROUP IN THE WHITNEY HALL OF OCEANIC BIRDS. This exhibit shows several guano islands in the Bay of Pisco, Peru, with their bird life. The guano-producing birds represented are the Peruvian pelican, booby and cormorant. Also included are the Peruvian penguin, Inca terns and two species of gulls

sandpiper, one of the smallest members of its family, of which two stand in the left foreground.

The Tuamotu archipelago occupies a huge area in the central South Pacific and is one of the most extensive island groups on earth.

Marquesas. A scene in the volcanic Island of Nukuhiva, showing a rugged shore line and ridges dissected by the sea, as viewed from a height of nearly 2000 feet. On the right is the Valley of "Typee," famous as the locale of Herman Melville's romance of the same name.

The birds include the giant pigeon (*Serresius*), which exists only at the island of Nukuhiva, a smaller native fruit pigeon, swifts of the "edible-nest" group, warblers and old world flycatchers peculiar to this island, a forest rail, a ground dove and a pair of wild chickens or jungle fowl, the ancestors of which were widely distributed in the Pacific by the original Polynesian immigrants.

Peruvian Guano Islands. Looking southward across the Bay of Pisco, Peru, from the southern island of the Chincha group. The scene represents the rainless coast of Peru, where climatic conditions are responsible for the accumulation on such islands of sea bird manure known as guano, which was the fertilizer of the Incas and other ancient agricultural peoples of the west coast of South America.

Despite the exhaustion of the old supplies of guano, it has again become an important commercial resource in Peru, and the industry is now operated upon a scientific conservational basis.

The three principal species of guano-producing birds, all of which are peculiar to the coasts of Peru and northern Chile, are shown. These are the Peruvian cormorant, booby, and pelican. Other birds of interest are the white-moustached Inca tern, two species of gulls, and on the rocks of the painted background a distant cluster of Peruvian penguins.

Galápagos. This scene is in the heart of the Galápagos archipelago looking from James Island across the water toward Albemarle, the largest island of the group. The Galápagos lie on the equator about 600 miles west of the South American coast. They are famous as the native home of many peculiar and long isolated species of both plants and animals, and they received their first notable scientific fame as a result of the visit of Charles Darwin in H.M.S. "Beagle" about 1834.

Man-o'-war birds, herons, an owl, mockingbirds and hawks are among the birds shown in the exhibit. Most of these are remarkable because of their total lack of shyness in the presence of man, a trait doubtless acquired during residence throughout a very long period in a land without man or other mammalian enemies. The most important of the Galápagos birds from a biological point of view are several species of small finches which show a great variation in the size of the bill. These mostly belong to the genus *Geospiza*, and Darwin's observations of them in the field are believed to have had much to do with his original ideas on the principle of natural selection as an explanation of evolutionary change.

Hawaii. This exhibit shows a deep and steep valley on the Hawaiian island of Kauai, with slopes and gorges descending about 4000 feet from the high plateau of the island toward low banks above the beach. The opposite or windward side of Kauai is extremely rainy and, on the right, fragments of storm clouds are shown whisking out over the valley which, however, is not very humid because most of the rainfall is precipitated farther to windward.

The Hawaiian archipelago, like that of the Galápagos, has been isolated from other land areas throughout many ages, and some of the native birds and other animals show even more peculiar and pronounced evolutionary changes. The Hawaiian honeycreepers (*Drepanididae*), for example, are obviously members of a single family of small land birds, yet the specializations in the bills of several species range from short, stout, almost parrot-like beaks to extremely long, pointed and sickle-shaped organs. Feeding habits are, of course, correlated with such structures, for the stoutest-billed species can manipulate hard seeds and



BROWN PELICANS *(Pelecanus occidentalis).* Brown Pelicans inhabit our coasts from South Carolina to the West Indies. They often fly in diagonal files and under favorable conditions sail long distances on set wings. Facing the wind, they travel high, but at times they skim just above the crest of curling breakers



EMPEROR PENGUIN *(Aptenodytes forsteri).* This is the largest of the existing species of the penguins. The mounted bird here shown, a male, weighed seventy-nine pounds. The Emperor Penguin is exclusively Antarctic, inhabiting the fringing ice of the south polar continent and the adjacent islands. It rarely sets foot upon land or rock. The single egg is laid on the ice in midwinter and is carried on top of the bird's foot until it hatches, the male and female taking turns at incubation

fruits, whereas those with long slender bills must use them in extracting nectar or small insects and spiders from the corolla of flowers. Several examples of these honeyeaters are exhibited, but it would be impossible to show the whole range of variation in bills without drawing upon species inhabiting other islands of the Hawaiian group.

At the right of the group three geese are shown in flight, the species being peculiar to Hawaii. In the air, down the valley, are two white-tailed tropic-birds, and the small land birds include one or more species having tufts of brightly colored feathers which were used by the ancient Hawaiians in manufacturing the famous feather cloaks worn by chiefs of high rank.

Laysan. Albatrosses, of which there are some seventeen species in the world, resort during the nesting season to remote oceanic islands. There they carry on their remarkably elaborate courtship procedure, lay the single egg, and rear their chick before they depart once more on

the oceanic wanderings which they continue until the return of the next breeding season.

Most albatrosses inhabit the higher latitudes of the southern oceans, and no species regularly enters the North Atlantic. The North Pacific Ocean, however, is the home of three kinds of albatrosses, two of which are here shown on the nesting ground of Laysan Island, a leeward outlier of the Hawaiian archipelago.

The two species shown are the white-breasted Laysan albatross and the all dark black-footed albatross. Both carry on an extraordinary ritual, commonly known as a courtship dance, although it really partakes of community behavior. The birds on the nesting ground salute, cross bills, and bow not only to their own mates but to other albatrosses of both sexes.

A pair of the small native teal of Laysan, found nowhere else in the world, is also shown in this exhibit. Others displayed are nesting sea birds, such as boobies, man-of-war birds, and petrels (which occupy burrows in the sandy soil), and shore birds that make the island a resting place during their long migration from Alaskan breeding grounds to a winter home among islands of the south seas—bristle-thighed curlews, golden plovers, and others.

New Caledonia. This large island, which is east of Australia, lies on one of the western Pacific arcs or submerged mountain ranges. It has had no connection with any other land area since it arose from the ocean in the early part of the Age of Mammals.

Because its life has been obtained by natural means from places across the sea, it is interesting to note that, among the 64 species of New Caledonian land birds, six belong to widespread Pacific species, 35 appear to have come from Australia, and 23 from the New Guinea region.

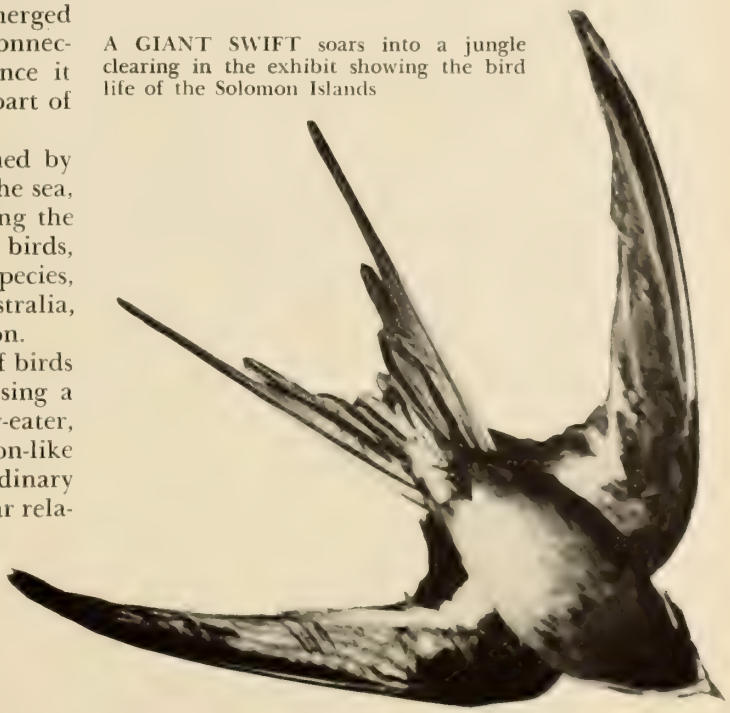
New Caledonia has five genera of birds found nowhere else, these comprising a pigeon, a parrot, a warbler, a honey-eater, and the strange, flightless, heron-like Kagu. The last is a very extraordinary bird, which appears to have no near relatives anywhere else in the world.

The site of this exhibit is on the northeasterly coast of New Caledonia, at an altitude of slightly more than 1000 feet. The birds, in addition to the Kagu (on the ground), include a fruit dove, kingfisher, cuckoo, warblers, flycatchers, whistlers, a wood-swallow, starling, honeyeaters, and a parrot finch.

Solomon Islands. Since the United States armed forces have made history at Guadalcanal Island, the savage Solomons no longer seem so far away as they formerly did. In this exhibit of bird life in a hot, humid, and mountainous archipelago, the background shows Guadalcanal itself. The foreground represents a small islet off the southeastern end of Guadalcanal, with a cluster of native huts, and a garden in which coconut palms, bananas, papaya, cassava, breadfruit, taro, and sweet potato are growing on the site of a recently-felled tropical forest.

The Solomon Islands have a rich bird fauna, with 128 species of land birds alone. The 21 species shown in the exhibit can therefore be only a representative selection. They include the following: the Brahminy kite, a bird of prey; the brush fowl or megapode, which lays its eggs in mounds of rotting vegetation, so that the heat of fermentation may hatch them; several species of doves, parrots, lories, and cockatoos, including the king parrot, of which the male is green

A GIANT SWIFT soars into a jungle clearing in the exhibit showing the bird life of the Solomon Islands



and the female vivid red; the giant swift, a relative of our American chimney swift; and various colorful representatives of Old World families, such as rollers, cuckoo-shrikes, flycatchers, sunbirds, and flower-peckers.

Australian Barrier Reef. The Great Barrier Reef, which for more than 1200 miles guards the east coast of Australia, is the largest coral reef in the world. In the extensive lagoon between the Barrier and the mainland are countless lesser reefs, islets of coral limestone and, near shore, higher islands which are detached fragments of the continental rock. Many of these have collected wind-blown soil and have acquired a luxuriant, even if limited, plant life. Others remain relatively bare but are still far enough above the reach of the ocean to furnish breeding grounds for great colonies of sea fowl.

The birds of the Great Barrier are mostly of widespread types, as is characteristic of the avifaunas of beaches and small islands. They include a noisy colony of brown noddies and sooty terns, the fledgling young of the latter being the dark speckled birds which look so unlike their parents. Australian silver gulls, crested terns, reef herons in both gray and white phases, and man-of-war birds complete the list of resident oceanic species. The sandpipers or tattlers in the beach pool are winter migrants from northern Asiatic nesting grounds. The white land birds painted in flight are nutmeg pigeons bound, perhaps, toward fruit trees growing on the islets.

THE GREAT BARRIER REEF. Most of the flying birds in this view are sooty terns. The darker ones are part of a colony of brown noddies





BIRDS OF NEW GUINEA. Three Alpine Lories, brilliantly colored New Guinea parrots, are perched above two Macgregor's birds of paradise

New Guinea. Among its 650 species New Guinea has many birds not known in Australia, though the two land masses are only 100 miles apart at Torres Strait. A drop of 50 feet in the sea level would probably join them. On a map of the United States, New Guinea would reach from New York City to Colorado, and its interior offers some of the largest unexplored areas on earth. This exhibit depicts a scene on Lake Habbema, 11,000 feet above sea level, looking southward toward Mount Wilhelmina.

Fiji. The Fiji archipelago is one of the largest, most beautiful, and most important in the Pacific. It forms part of one of the several great island arcs to the east of Australia and New Guinea and comprises more than 200 separate islands and islets. The larger members are mountainous, and many are surrounded by fringing reefs of coral.

Fiji has about 54 species of land birds, or only half as many as the Solomon Islands, which are hundreds of miles nearer the ultimate source of supply in the Australasian region. The principal Fijian types are birds of families known to be able to make long colonizing flights across the ocean, such as parrots,

pigeons, kingfishers, starlings, and white-eyes.

In the silky dove and the golden dove, Fiji has two of the most spectacular of all birds. Both species are peculiar to this group of islands, and one of them only to Viti Levu Island, the site of the exhibit. The thirteen additional birds shown all belong to families found at other Pacific islands, but the species are mostly peculiar to Fiji. Most of the aboriginal Fijian birds are confined to mountain districts, while the common birds of town and village are more widespread or recently introduced kinds.

Hall of Biology of Birds

(Index Plan, p. 16, Floor I, Hall 19)

The Hall of Biology of Birds, on the first floor of the Whitney Wing, is devoted to diagrammatic exhibits illustrating the bird's place in nature and many different aspects of the structure, descent, relationship and behavior of birds. Other animals will be made use of when desirable. For example, in the consideration of flight, the plan and technique of the flight of insects, bats, pterodactyls, etc. will be shown in conjunction with various types of bird flight.

At this date, the construction of exhibits in the Hall of Biology of Birds has just begun and the hall is still closed to the public except for the first two alcoves. In these are shown an exhibit devoted to the relationships of birds to their reptilian ancestors and the varying course that evolution has taken in different orders and families of modern birds, together with an exhibit entitled "Birds and Man."

Gallery of Bird Art

(Index Plan, p. 19, Floor IV, Hall 19)

A collection of original drawings and paintings of birds by Louis Agassiz Fuertes is installed in the Gallery of Bird Art on the Fourth Floor of the Whitney Wing. These works cover most of Fuertes' life as an artist, from a painting made while a young boy to his mature work of the later years preceding his untimely death. The collection includes numerous studies made in the field, many of them while on expeditions of the American Museum, and finished pictures, both published and unpublished.

The same hall contains a series of original water-color paintings by Joseph Wolf which were published as illustrations of various of the ornithological monographs of D. G. Elliot, particularly the Monograph of the Pheasants.

Included in this hall, also, are two large oil paintings from the collection of Audubboniana, most of which is installed in the ambulatory of the Theodore Roosevelt Memorial Wing immediately adjoining. One of these paintings is by John James Audubon, showing a dog surprising a group of pheasants. The other is a portrait of Audubon with his dog, horse, and gun from the brushes of his sons Victor and John Woodhouse Audubon.

Audubon Gallery

(Index Plan, p. 19, Floor IV, Hall 12a)

A noteworthy collection of objects relating to the life and work of John James Audubon is exhibited in the corridor on the fourth floor of the Roosevelt Memorial leading into the Whitney Wing. These include original sketches and paintings by Audubon, and by his son, John Woodhouse Audubon, mainly of the Quadrupeds of North America; some of the copper plates from which the Birds of America were printed, and a portrait of Robert Havell, their engraver and publisher of the first edition of the "Birds." Of special interest are the portraits of Audubon, one of which is displayed on the right-hand wall of the Whitney Gallery of Bird Art, just inside the entrance. Of more personal interest are the guns carried by Audubon on many of his expeditions and the buckskin suit he wore.

These objects were presented mainly by his grand-daughters, Maria R. and Florence Audubon, but the largest piece, a covey of pheasants, was given by Miss M. Eliza Audubon. Gifts have been received also from Dr. Edward H. Rogers, Miss Anne E. Roelker, Robert Havell Lockwood, and others.

Birds of the World Hall

(Index Plan, p. 17, Floor II, Hall 2)

This hall is devoted to a projected series of twelve habitat groups to show the major faunal areas of the world and their characteristic birds. Eleven groups have been completed. The backgrounds, by Francis Lee Jaques, Frank McKenzie, and Arthur A. Jansson, are reproductions of actual scenes made from color sketches and photographs taken on the spot. Beginning at the right of the entrance, the completed groups are as follows:

Pampas Group. The pampas and lagoons of the South Temperate Zone of South America harbor a varied assemblage of birds. These include some twenty species of North American sandpipers and plovers that migrate to this region to spend the northern winter. Some of the birds are permanent residents. The scene is laid at Lake Chascomus, near Buenos Aires, Argentina, a region made famous by the writings of William Henry Hudson, to whom the group is dedicated. It is a gift of Mrs. Anna E. Erickson.

High Andes Group. The Paramo Zone of South America is found at sea level at the southern end of the continent but occupies increasingly high elevations in the Andes, below the snow line, as the equator is approached. In the neighborhood of Mt. Aconcagua, Chile, shown in the background, this zone is reached at 10,000 feet elevation, but the birds are still closely related to those of the lowlands of Patagonia and southern Chile. The giant Condor is a characteristic species.

American Tropical Zone. Barro Colorado Island, in the Canal Zone, was once a hilltop and part of the unbroken humid tropical forest of the Panamanian lowlands but it was cut off from the surrounding forest when the valley of the Chagres River was flooded by the closing of Gatun Dam. It is now preserved as a natural laboratory under the care of the Institute for Research in Tropical America. It has been made known to many through the writings of Dr. Frank M. Chapman, particularly by his books, "My Tropical Air Castle" and "Life in an Air Castle."

South Georgia Group. The bird-life of the Antarctic regions is not as rich in species as that of the tropics but possesses certain very interesting forms, among which the penguins are outstanding. The group shows an assemblage of King Penguins on the island of South Georgia, 1200 miles east of Cape Horn. Among the other characteristic species are the Wilson's Petrel (one of the birds known to sailors as "Mother Carey's Chickens"), the Kelp Gull, Giant Fulmar, the curious Sheathbill, and (painted) the Wandering Albatross.

East African Plains. The easterly third of Africa is largely a grassy country dotted with thorny bushes and trees. The Kidong Valley, scene of the group, lies some 40 miles northwest of Nairobi, Kenya Colony, in the Great Rift Valley that extends from northern Tanganyika to the Red Sea and southern Palestine. The Ostrich, Marabou, Bustard, Courser, Secretary Bird, Hoopoe, Coly, and Lark shown in the group are typical of the plains region, though some of the other birds shown have close relatives in the forests. Gift of Mr. Henry W. Sage.

Congo Forest Group. The equatorial forests along the Congo River in western Africa are rich in bird-life. As in other tropical forests, many species of birds often band together in loosely mixed flocks that roam the woods for insects and other food, searching from the ground to the tops of the trees. The exhibit shows such an assemblage together with other inhabitants of the region. The scene is at Lukolela, about 500 miles upstream from the mouth of the Congo River. Presented by Mrs. Dwight Arven Jones.

Australia. This is a scene in the Blue Mountains of New South Wales, about 100 miles west of Sydney, at the edge of the forest looking out over the eucalyptus-dotted savanna. Two Lyre Birds (male and female) have come to the forest margin. A flock of Crimson Rosella Parrots has settled on the ground and in the trees, and two Eastern Rosellas are near-by.



MACAWS *(Ara macao)*. From the exhibit showing the bird life of Barro Colorado Island in the Panama Canal Zone. This island, made by the spreading of Gatun Lake, has cut off a portion of the continental tropical jungle with its abundant mammal and bird life

A DETAIL FROM THE SAN JOAQUIN VALLEY, CALIFORNIA, BIRD GROUP. This valley, once a vast desert, has now been irrigated. Well-watered grass lands have resulted, inhabited by birds in great abundance and variety



BIRD LIFE OF THE GOBI

Several Black-backed Magpies are on the ground or (painted) flying, and a Laughing Jackass is perched in a tree overhead. Various characteristic birds of eastern Australia are shown, such as the Peaceful Dove, Satin Flycatcher, Broad-billed Roller, Gang-gang Cockatoo, and others. In the distance (painted) are scattered the ostrich-like groups of Emus. The group was the gift of Archer M. Huntington.

Gobi Group. The extensive desert of central Asia, known as The Gobi, contains a number of brackish lakes, without outlets and fed by surface and underground streams from mountains such as the Altai Range shown in the background. The climate is cold except for a brief summer, and the bird-life consists largely of migrant species that go south for the winter, as the Demoiselle Crane, Great Bustard, and Ruddy Sheldrake. The Raven remains throughout the year. The interesting Sand-Grouse often travels long distances daily for water and has an irregular local migration.

Palaearctic Alpine Group. The Zermatt Valley and the Matterhorn, in Switzerland, are shown with some of the characteristic birds of the upper Alps at timberline at 7000 feet elevation. Some of the species, like the Wall Creeper and the Snowfinch, probably reached the Alps from the Himalayas in prehistoric times when these two now distant mountain ranges may have been continuous. Others, like the Arctic Ptarmigan and Redpoll, may have come from the north, driven by the advancing ice of the Glacial Period. Still others are inhabitants of the lower elevations that have extended their ranges upward to the timberline.

New Forest Group. The Palæarctic Zone or Old World North Temperate



GREAT AUK, or Gare Fowl, a bird now extinct. No living specimens have been recorded since 1844. (A mounted specimen in the American Museum)

Zone corresponds to the Nearctic or North Temperate Zone of North America. The families of birds found in the two regions are much the same and some of the species are identical although their local names may differ. Occasionally the same name is applied to quite different species as in the case of the European and American robins. The group shows the famous "Roosevelt Walk" in the New Forest, in the Valley of the Itchen, in Hampshire, where Lord (then Sir Edward) Grey and Theodore Roosevelt watched the birds together in 1910. The group is dedicated to Lord Grey and was the gift of Mrs. Carll Tucker.

Tundra Group. Churchill, Manitoba, on the western side of Hudson Bay, lies in what the Indian called the "land of little sticks." Here the Canadian forests to the southward are giving way to the treeless tundra that reaches northward to the Arctic Ocean. In summer the tundra is dotted with innumerable insect-filled ponds. Hither to nest come myriads of migratory water birds—sandpipers, plovers, gulls, ducks, and geese—that have wintered in warmer lands to the southward. A few land birds also nest on the tundra. One of these, the Arctic grouse or Ptarmigan, is able to endure the long Arctic winter and, unlike most of the tundra birds, does not migrate. A number of forest- or bush-dwelling birds reach the northern limit of their distribution near Churchill. Some of these may be seen in the group, the gift of William A. Rockefeller.

Hall of North American Bird Groups

(Index Plan, p. 18, Floor III, Hall 1)

Here are the Habitat Groups of North American birds, prepared under the direction of Dr. Frank M. Chapman, Curator of Ornithology, who collected most of the specimens and made practically all the field studies. The backgrounds are reproductions of specific localities, painted from sketches made by the artist who usually accompanied the naturalists when the field studies for the groups were made. Practically all sections of the country are represented; thus the series depicts characteristic North American scenery as well as the bird-life. The backgrounds of the groups were painted by Bruce Horsfall, Charles J. Hittell, Hobart Nichols, Carl Rungius, W. B. Cox, Louis A. Fuertes, and Francis L. Jaques. The foliage and flowers were reproduced in the Museum laboratories from material collected in the localities represented. (See Guide Leaflet No. 28.) The visitor should follow the series to the right around the hall.

Orizaba Group. The distribution of birds, notwithstanding their powers of flight, is limited in great measure by climate. Thus in traveling from Panama north to Greenland there are zones of bird-life corresponding to the zones of temperature. This condition is illustrated on the mountain of Orizaba in Mexico, where in traveling from the tropical jungle at its base to its snow-clad peak the naturalist finds zones of life comparable with those to be found in traveling north on the continent. Thus the Orizaba group, so far as the distribution of life is concerned, is an epitome of all the groups in the hall.

Cobb's Island Group. Among our most beautiful and graceful shore-birds are the terns and gulls, which (because of their plumage) were once ceaselessly hunted and slaughtered for millinery purposes. Thanks to protection, they have now greatly increased in numbers. The group represents a section of an island off the Virginia coast, where the birds are now protected by law.

Duck Hawk Group. The Duck Hawk may be found nesting on the Palisades of the Hudson almost within the limits of New York City. It nests on the ledges of the towering cliffs. This hawk is the Peregrine Falcon, which was so much used for hunting in the Middle Ages. It often comes into the city for pigeons.

Hackensack Meadow Group. In August and September the meadows and marshlands bordering the Hackensack River, New Jersey, formerly teemed with bird-life, but this is rapidly disappearing before the march of "improvements." In the group are swallows preparing to migrate southward, Bobolinks or "Rice Birds" in autumn plumage, Red-winged Blackbirds, Rails, Wood Ducks and Long-billed Marsh Wrens.



ARCTIC SEABIRD LIFE. From a group in the Gallery of North American Birds. The group depicts the lower part of a 1000-foot cliff on Little Diomede Island in Bering Sea. Here myriads of sea birds come each summer to lay their eggs and rear their young

Wild Turkey Group. The Wild Turkey is a native of America and was once abundant in the wooded regions of the eastern portion of the United States, but is now very rare. It differs slightly in color from the Mexican bird, the ancestor of our common barnyard turkey, which was introduced from Mexico into Europe about 1530 and was brought by the colonists to America. (Reproduced from studies near Slaty Forks, West Virginia.)

Florida Great Blue Heron Group. The Great Blue Heron usually nests in trees. The bird flies with its neck curved back on its body, and because of this habit it can readily be distinguished from cranes, with which it is frequently confused. (Reproduced from studies near St. Lucie, Florida.)

Water Turkey, or "Snake-bird," Group. In the yellow pond-lily swamps grown with cypresses and cabbage palmettos, the shy Water Turkey builds its nest. It receives the name "turkey" from

its turkey-like tail, and the title "snake-bird" from its habit of swimming with only the long slender neck above water. (Reproduced from studies near St. Lucie, Florida.)

Sandhill Crane Group. Unlike the herons, the Sandhill Crane builds its nest of reeds in the water. It differs also in its manner of flight, always fully extending its neck when on the wing. (Reproduced from studies on the Kissimmee Prâiries of Florida.)

Brown Pelican Group. Pelican Island, on the Indian River of Florida, has been made a reservation by the United States Government, and these grotesque birds now breed there in comparative safety. The view shows a section of the island at the height of the nesting season. (Reproduced from studies at Pelican Island, Florida.)

American Egret Group. This beautiful bird has been brought to the verge of extinction in this country through the use of its "aigrette plumes" for millinery purposes, and is now confined to a few protected rookeries in the South. The birds have these plumes only during the nesting season, at which time the death of the parent means the starvation of the young. (Reproduced from studies in a rookery of South Carolina.)

Turkey Vulture Group. The Turkey Vulture, or "buzzard," is one of the best-known birds of the South, where it performs a valuable service in acting as scavenger. On this account it is protected by law and by public sentiment and has become both abundant and tame. (Reproduced from studies at Plummer Island in the Potomac River, near Washington.)

California Condor Group. The California Condor is the largest and one of the rarest of North American birds. It is not so heavy as the condor of the Andes, and has a slightly smaller spread of wing. In the group the visitor is supposed to be standing in the interior of the condor's cave, and is looking down on the river of the cañon. (Reproduced from studies in Piru Cañon, California.)

Brandt's Cormorant Group. The foreground of the group shows a detail of the island that is painted in the background. The young birds are feeding, and it will be noticed that one fledgling is reaching down the mother's throat after the predigested food. (Reproduced from studies at Monterey, California.)

San Joaquin Valley Group. Formerly this area was an arid place with a characteristic desert bird fauna. Now the ranchmen have irrigated the land, and aquatic bird-life abounds. This group is a good illustration of the influence of man on the bird-life of a region.

Bering Sea Bird Group. Little Diomede and Big Diomede form a group of two islands which lie in Bering Sea, fifty miles south of the Arctic Circle and about midway between Alaska and Siberia.

The site of the group is the lower part of the 1000-foot cliff at the south end of Little Diomede. Here, protected by isolation, as well as by the nature of their haunts, myriads of murres, guillemots, puffins, auklets, gulls, and cormorants come each summer to lay their eggs and rear their young.

Flamingo Group. These were estimated to be two thousand nests in this colony. The Flamingos construct their nests by scooping up mud with their bills and packing it down by means of bill and feet. The nests are raised to a height of twelve or fourteen inches. This protects eggs and young from disasters due to high water. Only one egg is laid, and the young, covered with down, is fed by the mother on predigested food. (Reproduced from studies in the Bahama Islands.)

Booby and Man-of-War Bird Group. In this group is shown a portion of a coral islet on which three thousand Boobies and four hundred Man-of-War Birds were nesting, the former on the ground, the latter in the sea grape bushes. (Reproduced from studies in the Bahama Islands.)

Florida Rookery Group. In this group are Roseate Spoonbills, Snowy Egrets, American Egrets, Little Blue Herons, Louisiana Herons, ibises, cormorants, and Water-Turkeys. Because of the great inaccessibility of this island it was one of the last places to feel the depredations of

the plume-hunter. (Reproduced from studies in the Everglades of Florida.)

Whistling Swan Group. A Whistling Swan on the nest is visible far across the arctic tundra, the summer home of this species. The nest is built of moss, etc., and in it are laid two to five white eggs, four and a quarter inches long. Both male and female share the labor of nest-building, incubation, and caring for the young.

Whooping Crane Group. The Whooping Crane is so nearly exterminated that not only was it impossible to obtain a nest and young, but in making this group it was necessary to use specimens taken many years ago.

Golden Eagle Group. The Golden Eagle is one of the most widely distributed of birds. In North America it is common from the Rockies to the Pacific, as far east as Maine. Stories to the contrary notwithstanding, the eagle never attacks man.

Its food consists of rabbits, squirrels, woodchucks and occasionally sheep. (Reproduced from studies near Bates Hole, Wyoming.)

Klamath Lake Group. The bird-life here shows how normal nesting habits may be changed by birds being forced to live in a new locality. White Pelicans, which usually make a nest of pebbles, Caspian Terns, which commonly build their nests on sand, and Cormorants that nest on rocks are all nesting together here on the islets of the lake. Unfortunately the breeding ground shown here, with its wonderful bird-life, has been destroyed by ill-advised drainage. (Reproduced from studies at Klamath Lake, Oregon.)

Arctic-Alpine Bird-Life Group. The scene represented in this group is above the timber-line on the crest of the Canadian Rockies, 8,000 feet above the sea. Although these mountains are in the temperate region, the altitude gives climatic conditions that would be found in the Far North, and the bird-life is arctic in character. Here are nesting the White-tailed Ptarmigan, Rosy Snow Finches, and Pipits. (Reproduced from studies in the Canadian Rockies.)

Sage Grouse Group. This group shows a stretch of western plateau covered with sage brush. In this brush is seen the male Sage Grouse strutting and wooing a mate. (Reproduced from studies at Medicine Bow, Wyoming.)

Prairie Chicken Group. The Prairie Chickens are akin to the common grouse. The group represents a typical scene during the mating season. The male birds go through most surprising antics in their efforts to attract the females. They inflate the orange-colored sacs on the sides of their necks, dancing and strutting about and uttering a loud, resonant, booming note. (Reproduced from studies near Halsey, Nebraska.)

Wild Goose Group. The Wild Goose is one of the first birds to migrate north in the spring. It nests among the lakes of Canada even before the ice is melted. (Reproduced from studies made at Crane Lake, Saskatchewan, Canada.)

Grebe Group. The grebes are aquatic birds which build their nests in the water. During incubation the parent bird usually covers the eggs with grass and reeds when leaving the nest. Nesting at the same lake with the grebes was the Redhead Duck. (Crane Lake, Saskatchewan, Canada.)

Loon Group. The Loon is justly famed for its skill as a diver, and can swim with great speed under water. Its weird call is a familiar sound on the northern New England lakes. Many Loons pass the winter at sea fifty miles or more from land. (Lake Umbagog, New Hampshire.)

Bird Rock Group. This rocky island thirty miles from shore in the Gulf of St. Lawrence affords some protection to the sea birds which still nest in considerable numbers on its cliffs. Seven species are shown nesting in the group—the Razor-billed Auk, Leach's Petrel, Gannet, Puffin, Kittiwake Gull, Common Murre, and Brünnich's Murre. This was the Museum's first large group. (Bird Rock, Gulf of St. Lawrence.)

(See also Guide Leaflet No. 28, *The Habitat Groups of North American Birds.*)



CHIMNEY SWIFT

(Index Plan, p. 16, Floor I. Hall 12a)

In the corridor on the first floor of the Roosevelt Memorial are shown all the species of birds that have been known to occur within 50 miles of New York City. The first four lettered cases, A-D, on the right, opposite the entrance to the new Hall of North American Mammals, contain the permanent residents. The next four lettered cases, E-H, contain the migrants. The latter are changed as necessary about the first of each month. Beginning at the entrance to the Mammal Hall on the left-hand wall, the numbered cases contain the general collection of all birds found within this area.

A case containing the nests and eggs of the local birds will be found around the corner from case A, on the opposite side of the stairway leading to the second floor.



MOURNING DOVE



(Above) GREEN HERON
(Below) RED-WINGED BLACKBIRD

Local Birds

In the central Hall of this floor of the Roosevelt Memorial, to the right of the entrance, is the Roosevelt Sanctuary Group, showing characteristic spring migrants in the New York City area. The scene is laid in the Roosevelt Wildlife Sanctuary at Oyster Bay, Long Island, and shows the memorial fountain (reversed) and the site of Theodore Roosevelt's grave on the hillside to the left. The background was painted by James Perry Wilson, assisted by Fred F. Scherer.



(Above) WOOD THRUSH
(Below) KINGBIRD





BALTIMORE ORIOLE



LIVING MAMMALS

The Hall of North American Mammals

(Index Plan, p. 16, Floor I, Hall 13)

The new Hall of North American Mammals was opened to the public April 8, 1942, although a number of the groups are still unfinished.

At the west end of the hall, opposite the entrance, is the **Alaska Brown Bear Group.** These great carnivores are shown against the background of the Pinnacles, precipitous mountains of the Alaska Peninsula. A salmon lies on the shore of a small creek, also an Otter, frightened from its catch by the bears.

On each side of the entrance to the hall are small-scale groups, showing the mammals of North America and their environment during the Ice Age. These animals are now extinct in North America, although their close relatives exist in other parts of the world. The group to the right shows the mammals that existed in Alaska, the group on the left those that occurred in southern California.

The first large group to the right of the entrance exhibits the **Grant Caribou.** The landscape is the Alaska Peninsula.

Next is the **White Sheep Group.** Hand some rams are resting on a mountain with a "midnight sun" striking the top of Mount McKinley, Alaska, in the background.

The **Rocky Mountain Sheep Group** shows how unlike in color and details of structure related species may be. The massive, closely spiraling horns of the Bighorn contrast with those of the White Sheep. In the foreground may be seen a Say Ground Squirrel, or "big chipmunk" as it is locally called.

The **Alaska Moose Group,** around the corner, shows two bulls locked in a struggle for mastery, while a cow moose, interested but not concerned over the outcome, looks on. The number of moose that are painted in the background convey an idea of their abundance on the Kenai Peninsula, where the scene is laid. A Canada Jay, or Whiskey Jack, may be

ALASKA BROWN BEAR. The world's largest carnivore. It goes into hibernation high on the mountain slopes in the fall and emerges in April or May





THE BIG-HORN SHEEP inhabits the rugged mountains far above the tree line and only descends when forced down by deep snow. The scene portrayed for this group in the American Museum is in Jasper National Park, Alberta

seen in a bush to the right of the fighters, and a spruce grouse is in a tree to the left of the cow.

The **Grizzly Bear Group,** with a male, a mother bear, and her two cubs, is around the corner to the right. They are on the edge of the Canyon of the Yellowstone in the National Park. The Falls are shown in the distance, and an osprey, or fish hawk, is painted in the middle distance. The nest of this bird may be seen on a rocky pinnacle in the canyon.

Next is the **Jaguar Group,** showing a pair of these large, spotted cats on a rocky mountainside in Sonora, Mexico.

The **Mountain Lion Group,** exhibiting a pair in a shallow cave, has as a background the picturesque Grand Canyon of the Colorado. One of the cats is interested in the movements of a deer, far below, while the other lies on the floor of the cave.

Behind the Alaska Bear Group is a small passageway containing a faunal map of North America and photographs of mammals in the wild.

The **Wapiti Group** is on the opposite side of the hall from the Mountain Lion Group. A splendid bull Wapiti, or American Elk, several cows, and calves of the year are shown in the northern Colorado Rockies.

The **Virginia Deer,** or Whitetail, occur in numbers as close to the metropolitan area as Bear Mountain Park. A buck and two does are exhibited in the group amid the brilliantly colored foliage of the eastern fall.

The Devil's Tower in northeastern Wyoming is the scene portrayed as the setting for the **Mule Deer Group,** which is under construction as this Guide goes to press.

The next group shows **Bison** and **Pronghorn Antelope** on the North Platte River, Wyoming. Vast herds of Bison as

shown here formerly roamed from the Appalachians to the Rockies and from Mexico into the Canadian Northwest. A prairie dog is poking its head out of a burrow, and cowbirds are associated with the bison.

Around the corner is the **Musk Ox Group.** Well equipped for life in the rigorous arctic regions with their long, dense coat of fur and hair, these animals are at home in the blizzard in northern Ellesmere Land.

Both **Black-tailed** and **Antelope Jack Rabbits** may be seen next, on the lower slopes of the Rincon Mountains, southern Arizona, among saguaro and barrel

THE MUSK OX is now restricted to certain parts of Arctic America, though in the Ice Age it ranged over most of Europe, Asia, and what is now the United States



cactus, ocotillo, and other desert plants. (The group is only partly completed as this goes to press.)

The **Rocky Mountain Goat Group** exhibits a billy, a nanny, and a kid on a mountain in southern Alaska, overlooking a beautiful fiord, the Endicott Arm.

The **Osborn Caribou Group** has as background the mountain grasslands of northern British Columbia. These caribou move down into the forest during heavy storms, but do not migrate like the caribou of the Barren Lands. A flock of ptarmigan may be seen in the background.

THE MOUNTAIN GOAT is famous for its climbing ability. The animals in the Museum exhibit reproduced here are shown on a precarious ledge overlooking the Sawyer Glacier in Alaska





MOUNTAIN GORILLA *(Gorilla gorilla beringei)*. Of all living animals, the gorilla appears to be most nearly like man. The adult males may reach a weight of 500 pounds. Their strength is tremendous, and they are dangerous when enraged. They are found in the rain forests in the highlands of the eastern Belgian Congo. Terrestrial in habit, they feed on fruits and herbage.
Detail of group in Akeley African Hall

The Akeley Memorial Hall of African Mammals

(Index Plan, p. 17, Floor II, Hall 13)

The main floor of this hall, entered from the Theodore Roosevelt Memorial Building, was opened to the public in the spring of 1936. Here are recreated examples of the mammals typical of Africa, in their natural surroundings.

At each side of the two doors are sculptured representations of African natives by Malvina Hoffman.

In the center, dominating the hall, stands a herd of **elephants** in characteristic formation when alarmed. The great bull is testing the air for scent, while a younger bull wheels to cover the rear of the herd from possible attack.

Immediately to the right of the entrance is the **Water Hole Group.** The animals of the dry plains must come to such seepage holes to drink. Here are reticulated giraffes, Grant gazelles, oryx with long straight horns, and Grévy zebra. Other typical mammals are seen in the background, and several sand grouse in the foreground.

Next are seen the handsome antelopes, **Mountain Nyala,** on the heather-covered uplands of Abyssinia.

A herd of **African Buffalo** is next, emerging from the marshes along the Tana River, Kenya, in late afternoon.

A **family group of Lions** resting in the shade of a tree is the following scene, typical of the great plains of East Africa. In the background a herd of antelopes and zebra feed unconcernedly.

The **Bongo Group** shows a pair of these handsome antelopes in the bamboo forest high on the Aberdare Mountains, Kenya. They have disturbed another typical forest-dweller, the giant forest hog.

The next group on the right-hand side of the hall shows a fine pair of **Giant Eland,** the largest of the antelopes, in their natural habitat in southern Sudan.

The **Upper Nile Region Group.** Waterbuck, kob, Nile lechwe, tiang antelope, sitatunga, roam antelope, and hippopotamus are shown in this exhibit. A tributary of the Nile, with crocodiles, forms the background.

At the end of a short hallway there is a large-scale map of Africa, showing localities from which the various animals and their settings were taken.

On the left-hand side of the hall, beginning at the far end, is the **Plains Group.** Here is depicted the teeming mammalian life of the East African plains. The several kinds of antelope and the zebra in this group are typical of this part of Africa.

The **Greater Koodoo** bears the longest horns of any African antelope. An old male with a female and young male are placed here in a setting duplicating the rough, scrub-covered hills where these animals were collected.

The **Giant Sable** is noted for its handsome form, rich color, and long, saber-like horns. It is found in the dry, park-like country of central Angola, in a limited area, and is rapidly becoming extinct.

The **Gemsbok** is a larger relative of the oryx seen in the Water Hole Group. Although once widely distributed in South Africa, it is now common only in the dry Kalahari Desert.

Next is the family of **Okapi,** the strange forest-dwelling relatives of the giraffe.

In a typical scene in the **Libyan Desert** are shown several addax, which possess spirally twisted horns, also scimitar-horned white oryx, and addra gazelles.

The **Gorilla** family is of particular significance to human beings, because these great apes are perhaps the most like man of all the living animals. They are shown here in a clearing in the dense rain-forest of the Kivu Mountains, an exact reproduction of their natural habitat.

Mezzanine, Akeley African Hall

(Index Plan, p. 18, Floor III, Hall 13)

The first group on the right shows the **Klipspringer,** the small, rock-climbing antelope in the right background. East African Baboons are in the right foreground, and a pair of Mountain Reedbuck appears on the left. Among the rocks in the left foreground may be discovered a hyrax, or cony.

The next is the **Cheetah Group,** which shows a pair of these fast running cats inspecting a family of nyalas which have just emerged from the forest. This scene is near the lower Zambesi River in Mozambique.

THE REAR GUARD. Detail from the great elephant group in the Akeley African Hall. In every herd of elephants, in the wild condition at least, one animal takes the responsibility of wheeling about at frequent intervals to see that all is well behind. The young male shown below is mounted in this position in the elephant herd. It was collected by John T. McCutcheon in 1910 when he was in the field with Carl Akeley



AFRICAN BUFFALO *(Syncerus caffer)*. Detail of the group in Akeley African Hall



GREATER KOODOO GROUP *(Strepsiceros strepsiceros)*

A party of **Chimpanzees** are shown in their arboreal habitat overlooking the Cavally River. This river forms the boundary between the Ivory Coast and Liberia. The animal at the right is in the process of building a nest.

In the next habitat group we see several **Lesser Koodoo,** the males of which have twisted horns. There are two gerenuk in the group, strange, long-limbed and long-necked gazelles with a small head. A flock of Vulturine Guinea Fowl is seen in the background.

A scene from the dense rain forest of the Cameroons shows a group of **Mandrills** foraging for food. The females of these baboons are much smaller than the males. In the front, at right, one of the young animals is surprised by a Gaboon viper.

Impala prefer the park-like country in which they are shown. With handsome carriage and lyre-shaped horns, the males rank among the most beautiful of the antelopes.

The **White or Square-mouthed Rhinoceros** is third in size among living land mammals. In front of this family group is an African Porcupine.

On the other side of the passage, at the end of which is a large map of Africa, a **Black Rhinoceros** family can be seen enjoying a mud wallow. A pair of long-nosed Dik-dik are included in this group.

Next there is a **Hunting Dog** pack at evening looking over the plains to where herds of Wildebeest and Zebra can be dimly seen. The dogs rarely bother these larger species; gazelles, impala, and smaller animals are their usual prey.

The **Hyaena-Jackal-Vulture Group.** Out on the Serengeti Plains, Tanganyika, a pair of lions have killed a zebra, and as they are withdrawing after completing their feast, the scavengers arrive for their share of the spoils. The animals and birds in this group include a Spotted Hyaena, two Black-backed Jackals, White-backed Griffon Vultures, a Rüppel's Griffon Vulture, two Eared Vultures, a Hood-Vulture, a Marabou Stork, and a White-collared Raven.

WHITE RHINOCEROS GROUP *(Ceratotherium simum cottoni)*



The next group exhibits a pair of **leopards** about to spring upon an unsuspecting **Bush Pig.** The scene is on the edge of a small swamp in the Aberdare Mountains, Kenya.

The **Colobus Monkey Group** shows a troop of these showy black and white monkeys among the branches of a tree overlooking a section of the Aberdare Mountain Forest, Kenya.

The **South African Group** shows typical mammals of the high veldt as they were when white men first came. Now the Springbok are greatly restricted in numbers and Blesbok and Black Wildebeest are found only on a few farms where they are protected.

The **Ostrich Group** shows a pair of these large birds with young ones just hatched from the eggs. The wart hogs would relish a few young ostriches, but the parents stand guard belligerently.

ROAN ANTELOPE: a graceful animal found over a large part of Africa from the Sudan south to Rhodesia.





"CAMEL" of East Africa: the gerenuk is said not to drink even in the well-watered Tanganyika country.

Vernay-Faunthorpe Hall of South Asiatic Mammals

(Index Plan, p. 17, Floor II, Hall 9)

We enter this hall from the left end of the Roosevelt Memorial Hall.

From 1922 to 1928 Mr. Arthur S. Vernay and Colonel J. C. Faunthorpe of Great Britain made six expeditions into India, Burma and Siam to collect and later donate to the Museum this collec-





DETAILS FROM WATER HOLE GROUP IN AKELEY AFRICAN HALL

(Above) GREVY ZEBRAS
(Opposite page) GIRAFFES AND GAZELLES AT A WATER HOLE

tion, which now stands as the finest and most complete exhibition of the larger South Asiatic Mammals in existence.

The groups and architectural setting were designed and executed under the direction of James L. Clark. The accessories were constructed under the direction of Albert E. Butler.

Dr. Harold E. Anthony, Curator of Mammals, was responsible for the scientific direction.

Two fine examples of the **Indian Elephant** stand in the center of the hall, giving due prominence to the largest and perhaps most characteristic mammal of southern Asia. This species differs from the African Elephant by smaller ears, higher forehead, and arched back. It has also different teeth and a trunk with only one "finger."

The **Nilgai** or **Blue Bull Group** is also centrally placed. This is the largest Asiatic antelope. It exhibits marked sexual divergence in color, the female and young being reddish fawn, the male a blue gray. The Nilgai is related to the African twisted-horn antelopes like the Koodoo and Eland.

The **Indian Leopard** differs only slightly from those found in Africa. Both are forest animals but occur in the dry bush country also. They feed on deer, pig, and the larger birds such as the peafowl that has been captured by the leopard in this group.

The **Sambar** is the largest of the Indian deer, found throughout the wooded part of southern Asia. Its size makes it an important source of food for the larger carnivores, but it is powerful and, when brought to bay, may be dangerous. The red Wild Dog of India hunts in packs,



sometimes as many as forty strong. In combination these fierce animals attack and kill animals as large as the Sambar.

The **Black Buck** (the adult male alone is blackish, the females and young males being yellowish-brown) is found in the high plains country. Here also lives the Chinkara, the Indian gazelle.

The **Muntjac,** or **Barking Deer,** is one of the most primitive of the true deer. Males, in addition to bearing small antlers, supported on bony pedicels, have well developed canine teeth. The Mouse "Deer" or Chevrotain is not a deer, but is probably more closely related to the camels.

The **Lion** formerly had an extended range in northern India, chiefly in the plains country. It is usually pale in color, but does not differ greatly from the several races found in Africa.

The **Four-horned Antelope** is the only living wild four-horned animal. It is found in small groups in most wooded and hilly parts of India but not in dense jungle. The **Smooth Otter** is found south of the Himalaya Mountains in India, Burma and the Malay Peninsula.

The **Chital** or **Axis Deer** is one of the most handsome of the deer family. The young of all deer are spotted, but this species retains the spotted pattern through life. It frequents the bamboo jungle and wooded regions near water, and is found in suitable habitats throughout most of India and Ceylon.

The **Gaur** is perhaps the largest of the existing cow-like animals, large bulls standing over six feet at the shoulder. Gaur are found in forested hilly country from India to Indo-China and the Malay Peninsula.

Water Buffalo occur in the lowlands and swamps of central India, Ceylon, and the Malay Peninsula. Buffalo have been domesticated and used as beasts of burden and milch animals. Wild Buffalo are the most dangerous Asiatic bovines to hunt, for they frequently charge. A herd will attack a tiger without hesitation.

The great one-horned **Indian Rhinoceros** is characterized by thickened skin

(Left) THE LEOPARD GROUP IN SOUTH ASIATIC HALL

(Below) SAMBAR ATTACKED BY WILD DOGS





THE GAUR *(Bos gaurus)*. The Gaur is an imposing animal of India, Burma and the Malay Peninsula. It is found in the forests, but sometimes feeds in grassy areas on the high hills. It is not found in the lowlands

which has the appearance of plate armor. Its prehensile upper lip indicates that it feeds partly at least on leaves and twigs, but it is found chiefly in the grass-jungles of Assam.

The **Banting** is perhaps the most like the domestic cow in appearance of all the wild bovines, and may be ancestral to the Indian cattle. It is, however, closely related to the Gaur, but is found chiefly in flat country and at lower altitudes. Banting are found from Burma and Cochin China to Bali in the Malay Archipelago.

The **Eld Deer,** or **Thamin,** is distinguished from other species by the graceful curve of the antlers in the male. It is found on the alluvial plains and in suitable localities east of the Bay of Bengal, from Assam and Manipur to Cambodia, Hainan, and the Malay Peninsula.

The **Sumatran Rhinoceros** is related to the Indian species but has two horns and is much smaller in size. It is found in Assam, Burma, Siam, the Malay Peninsula, Sumatra and Borneo, but is rare and secretive. It is found exclusively in forests.

The **Sloth Bear,** or **Honey Bear,** is characterized by the long flexible muzzle, which is used to suck termites from their deep runways. These animals feed almost exclusively on insects, fruit, and honey. They climb trees with difficulty. Bears are usually timid, but if wounded or cornered may be dangerous antagonists.

The **Hog Deer,** or **Para,** is a small relative of the Sambar and is found in the Indo-Gangetic Plain, the flat country in Burma, and much of Indo-China. It is usually solitary in habit.

The **Indian Wild Boar** is closely allied to the Eurasian Boar, but has a higher crest. It is one of the most "gamy" of the Indian mammals, fighting until killed.

Gibbons are the most primitive of the anthropoid apes, but the most arboreal. They are capable of walking upright, but travel by swinging from branch to branch and tree to tree. The Hoolock Gibbon inhabits the hills of Assam, Burma and southern Yunnan. Males are black, with white brows, but females are often pale yellowish-gray.

The **Swamp Deer,** or **Barasingha,** is related to the Thamin, but differs in the shape of the antlers. It is a large species, restricted to the vicinity of water in open forest, and on grassy plains. The Sambar is usually found in wooded regions, but is the most widely distributed species.

The **Tiger** is the largest Asiatic cat. Tigers live characteristically in the forest

and tall grass country, the stripes blending closely with the light and shadow of this habitat. They feed largely on deer and pigs but frequently kill domestic cattle. Individuals too old or decrepit for their usual prey may turn man-eaters.

Hall of North Asiatic Mammals

(Index Plan, p. 17, Floor II, Hall 5)

This hall is approached through the South Asiatic Hall from the Roosevelt Memorial. At present it is incomplete, but, when finished, the exhibits will cover the region north of the Himalayas, including Tibet, Afghanistan, Mongolia, and Siberia.

The **Giant Panda Group** is on exhibition and a **Siberian Tiger Group** is being prepared. Both of these are illustrated on pages 114-115.

Allen Hall of North American Mammals

(Index Plan, p. 17, Floor II, Hall 3)

As described elsewhere in this Guide, a new Hall of North American Mammals is now open on the first floor, the entrance being from the center of the Roosevelt Memorial section. However, other exhibits of North American mammals can still be seen in the Allen Hall on the second floor, adjacent to the North Asiatic Hall just described.

The first center exhibit to catch the eye is a group of American Bison and beyond this the Moose from New Brunswick. These groups, mounted years ago, are still among the largest examples of their kind and are noteworthy accomplishments of the older taxidermy, especially as pioneer achievements in that art.

Mountain Sheep. Mountain Sheep inhabit the more inaccessible mountain ranges of the West, from northern Mexico through the Bad Lands and Rocky Mountains almost to the shore of the Arctic. They are gregarious, occurring in small flocks. When undisturbed, each flock is headed by a ram, but when danger threatens, he assumes the rear guard and a ewe takes the lead.

Rocky Mountain Goat. This animal is a goat-antelope, with its only close relatives in the Himalaya Mountains. It is found from Idaho to Montana northward through British Columbia to the mouth of Copper River, inhabiting deep mountain ranges and inaccessible peaks.

Roosevelt Elk. At the end of this hall is a group of Roosevelt Elk found in the Coast Range from British Columbia to Northern California. Once abundant, they have become much reduced in numbers, though an effort is now being made to preserve them.

Beaver. The Beaver, formerly the most important of North American mammals from a commercial standpoint, and one intimately connected with the early history and exploration of the continent, is represented actively at work. The opening

ASIATIC WATER BUFFALO *(Bos bubalis)*. These buffaloes are the cattle of the grassy plains of India. They are widely domesticated as draft animals and furnish milk to the natives. They have been employed for hunting the Indian lion





THE GIANT PANDA *(Ailuropoda melanoleuca)*. This interesting creature lives in the bamboo forests growing on the sides of the mountains of western China. Though it resembles a bear in outward appearance, anatomical studies show that it is more closely allied to the raccoon



HEAD OF SIBERIAN TIGER. To be shown in a group for the North Asiatic Hall

in the lodge is not natural, but made to show the interior.

Cats, Wolves and Foxes. The cats, wolves and foxes, and the host of small creatures like squirrels, rats and mice, are represented by numerous characteristic examples. Here are the Jaguar, the largest of the American cats, the Puma, the well-known Coyote or Prairie Wolf and the little-known white Arctic Wolf from the extreme north of Greenland. Here too is the Arctic Fox in its two color phases.

Timber Wolf. One of the most beautiful groups in the Museum is that showing part of a pack of Timber Wolves following the tracks of deer.

Virginia Deer. The Virginia or White-tailed Deer, found over a large part of North America, is shown in its summer coat. Other species of our deer are displayed in the adjoining cases.

Peccary. The Peccary, one of two species related to the pig family and peculiar to the Americas, is really an intruder from South America.

Grizzly and Alaskan Brown Bears. At the end of the hall are the Grizzly and Alaskan Brown Bears, the latter the largest members of the family, as well as a splendid specimen of Giant Moose of Alaska.

Grant's Barren Ground Caribou. The Barren Ground Caribou are animals of the waste and treeless regions of Arctic America where it is impossible for other members of the deer family to exist. At regular intervals these animals gather in immense bands and migrate, going northward in spring and southward in the fall.

Musk Ox. The Musk Ox is adapted for life in the far north and usually travels in bands of a dozen or more. Its food in summer consists mainly of grass, in winter of trailing willows, pawed up from under the snow. The specimens in the group were collected by Commander Robert E. Peary on Bache Peninsula, Ellesmere Land, October, 1898.

Pronghorn Antelope. The handsome Pronghorn Antelope, peculiar to North America, once found in vast numbers on the western plains, was verging on extinction but is now increasing in numbers.

Muskrat. Owing to its wide distribution, the rapidity with which it breeds, and the growing scarcity and increasing demand for furs, the muskrat has become one of the most important fur-bearing animals.

Black Bear. A group at the right-hand side of the hall shows general color variations of the Black Bear. Among these are the Cinnamon Bear, the Glacier Bear, and Kermode's White Bear.

Puma. The Puma is very wide-ranging, being found over a great part of North and South America. In its many forms or species, it displays great adaptability to environment and is found not only in heavily forested districts and high mountains, but on arid desert areas as well.

Polar Bear. The Polar Bear inhabits the coast of the Arctic Ocean, wandering over the great ice-floes and along the shores of northern islands seeking seals and young walrus. The huge flat paws and powerful muscles make the animal a strong swimmer. The coat of long, almost woolly hair and a thick layer of fat protect it from the intense cold. The large male in the group was brought from Payer Harbor, Greenland, in the spring of 1902 by Commander Robert E. Peary.

Oceanic Mammals

(Index Plan, p. 16, Floor I, Hall 10)

Leading from the Hall of Fishes is the **Hall of Ocean Life.** In this hall are displayed whales, porpoises, marine mammals, the great coral reef group, and shells. Although much of the space is now occupied by permanent exhibits, the final plans have not yet been fully consummated, and additions to the exhibits in the hall will be made from time to time.

Immediately upon entering, the visitor will note the large skeletons and models of whales and porpoises suspended from the ceiling. Just in front of the entrance to the hall is the striking full-size model of the **Killer Whale,** with contrasting black and white markings—a fierce predatory cetacean capable of swallowing a fur seal or small porpoise at a gulp. Near the Killer and facing it hangs the model of a **Blackfish,** like the Killer a species of giant porpoise but of a much milder disposition. Skeletons of these animals are hanging beneath the models. Above the balcony in front of the entrance is suspended a lifelike model of a **Giant Squid,**



HARPOONING THE SPERM WHALE DURING THE DAYS OF SAILING SHIPS. One of a series of murals in the Hall of Ocean Life depicting whaling in olden times when sail-rigged vessels were used and the whales were killed with a harpoon thrown by hand

a great marine invertebrate upon which the Sperm Whale preys. The large skeleton to the right is that of a **Sperm Whale,** the largest of the living toothed whales, formerly much sought by whalers as the source of spermaceti. Beyond the Sperm Whale, on the same side, hangs a skeleton of the **Finback Whale.**

Just above these two large skeletons are found skeletons of several species of toothed whales, including several rare types, and the **Narwhal.** At the near end of this row is a model of the Sperm Whale, and at the far end is a small model of the **Sulphur-bottom Whale,** the largest animal in the world.

Along the left side of the hall, three skeletons of whales are suspended. The one nearest the entrance is a **Right Whale,** that in the middle a **Pigmy Right Whale,** and the third a **California Gray Whale.** Above them is a long row of life-like models of porpoises ranging in species from the common dolphin to the rare river and lake dolphins. Here also is a model of the **Pigmy Sperm Whale.** At the far end are two large models, one of the spectacular **Narwhal** with long ivory tusk (at the right), the other the **False Killer,** formerly a very rare species but in recent years appearing unexpectedly off the British Isles and the coast of South Africa, where a large number were stranded in shoal water. At the opposite end, on the left of the entrance, is a model of the **White Whale,** a large northern porpoise.

(Below) SKELETON OF THE ATLANTIC RIGHT WHALE *(Eubalaena glacialis).* The "whalebone" is shown in the skeleton suspended from the roof of the mouth as close-set, horny plates





A BULL WALRUS FROM THE PACIFIC WALRUS GROUP IN THE HALL OF OCEAN LIFE.
One of the specimens secured by the Stoll-McCracken Expedition to Bering Sea. Group presented by Mrs. Andrew Carnegie

Around the walls of the balcony are spaces for twelve mural paintings, of which nine have been completed. Along the right side are four great paintings showing scenes typical of **American Sperm Whaling** and titled respectively, "The Chase," "The Attack," "Towing the Carcass," and "Trying Out." On the left wall are three canvases portraying the life of **Typical Species of Whales** and including "Bowhead Whale," "Finback Whale," and "Killer Whales attacking a Gray Whale." These seven murals are the work of Mr. John P. Benson, the noted marine painter.

At the far end of the hall is the large habitat group showing a **Coral Reef in the Bahamas.** The group extends from the main floor of the hall up to the limits of the balcony ceiling and shows the multitudinous life below the surface, as well as the land, sea and sky above. This group was completed after twelve years study and preparatory work. (See page 62.)

Below the level of the balcony and hanging just beyond reach from the rail at the head of the stairway is a cast of a **Young Sperm Whale** which came into New York Harbor and eventually was held a captive in the Gowanus Canal at Brooklyn. It was brought to the Museum in the flesh.

On the main floor of the Hall of Ocean Life and under the balcony are the habitat groups of marine mammals. Beginning at the first right corner, the first of these is the group of **Northern Elephant Seals,** huge, ponderous mammals hauled out on the rocky beach of Guadaloupe Island, Lower California. The full-grown male of this species has a long, pendulous proboscis suggestive of an elephant's trunk. Continuing along the right side of the hall, the next exhibit is that of the **Florida Manatee,** a thick-set, homely beast, well adapted to its aquatic life. Next is the group of **Pacific Walrus,** one of the largest in the Museum, which shows these Arctic Sea mammals at home on an ice floe.

In the first left corner is a large group of **Steller Sea Lions** at home on St. George Island, one of the Pribilofs. The male Sea Lions are huge, powerful seals with massive necks and shoulders.

Adjacent to the Sea Lions are found the **Alaska Fur Seals** on Kitovi Rookery, St. Paul's Island, Many details of the home life of these beautiful seals are to be noted in this group, which shows the vigorous dominant bulls, each with his harem of sleek, slender cows, the bachelor bulls, and the playful pups.

On the floor of the hall are several cases with special exhibits. One of these is the **Townsend Fur Seal,** a species on the verge of extinction and only recently rediscovered after it was believed by many to have disappeared completely. Another case displays several types of diving gear with full equipment of pump, telephone, etc.

At either side, at the right side of the hall, main floor, are two cases with the beautiful **Undersea Paintings** by Mr. Zarh H. Pritchard.

Suspended from the ceiling at the far end of the hall is the **Lindbergh Plane, "Tingmissartoq."** This, together with the equipment used in flying across Bering Strait to China, and later in exploratory flights over Greenland, Iceland, the North Atlantic, Europe, the South Atlantic Ocean and South America, was the gift of Colonel and Mrs. Charles A. Lindbergh.

Other exhibits in the Hall of Ocean Life are described on pages 61-64.

Synoptic Hall of Mammals

(Index Plan, p. 18, Floor III, Hall 3)

This hall, entered from the Insect Hall, is devoted mainly to a series of exhibits illustrating the characters of mammals, their principal groups, or orders, the main subdivisions of these, known as families, and various interesting peculiarities of habits and structure. Each family is, so far as possible, represented by a mounted specimen and a skeleton. Starting from the further end and walking around the room from left to right, one passes from the egg-laying Platypus to man, represented by the figure of an Australian native, armed with the characteristic boomerang. Certain exhibits demonstrate modifications of form and structure for various modes of locomotion, and superiority of the brain of mammals over that of other vertebrates. Others show illustrations of albinism and melanism; that animals outwardly similar may be only very distantly related; how the coat of the hare changes from brown to white; and the adaptations of plants and animals to a desert habitat.

(Below) A toy-size antelope, Swayne's dik-dik, which is a close relative of the Giant Eland, weighing 1200 pounds: one of many interesting exhibits in the Synoptic Hall



Of special note is the skeleton of Jumbo, the largest elephant ever brought to this country alive.

The fruit bats, often known as flying foxes, the largest members of the Chiroptera, and found only in the warmer parts of the Old World, are represented by a small portion of a colony from Calapan, Philippine Islands. Such a colony may number several thousands, and may be very destructive to bananas and other fruits.

The most striking object in the hall is the life-size model of a **Sulphur-bottom Whale,** seventy-six feet in length. The original of this specimen was captured in Newfoundland, and the model is accurately reproduced from careful measurements. This species of whale is not only the largest of living animals, but, so far as we know, the largest animal that has ever lived. A specimen of this size weighs from sixty to seventy tons, twice as much as *Brontosaurus.* Although whales and porpoises live in the water, they are not fishes, but mammals, as they are warm-blooded and breathe by means of lungs, not gills.

Mammals of New York State. A complete series of the living animals which have been known to exist within the limits of New York State is presented in the corridor on the first floor of the Roosevelt Memorial in the neighborhood of the elevators (Index Plan, p. 16, Floor I, Hall 12a). This exhibit includes skins of all animals of moderate size, models of the larger species and cutout figures of the whales and other large sea animals, the latter recorded from the waters around New York.

ORIGINS OF MAN

Hall of Primates

(Index Plan, p. 18, Floor III, Hall 2)

The Systematic Series of Primates, intended to give some idea of the number of species in this order, and their range in size, form, and color, begins on the left with examples of gorillas and chimpanzees and is continued in the wall cases around the room, ending with the lemurs. Noteworthy among the Primates is the Gorilla, largest and most powerful of apes; the curious "Proboscis" Monkey from Borneo; and the Aye-Aye of Madagascar.

The center corridor contains groups of Primates characteristic of various parts of the world, Africa, Asia, South America and Madagascar, and a group of Pygmies living in the forest in central Africa.

Outside of the central corridor, on the left side of the hall, is a group of Orang Utans from Borneo.

At the farther end of the hall, a series of skeletons demonstrates the comparative structure of the Primates and the changes that take place in passing from Lemurs to Man.

Temporarily placed in this hall also is an exhibit of domesticated dogs, which, though a small one, includes some noteworthy examples of various breeds.

Hall of the Natural History of Man

(Index Plan, p. 18, Floor III, Hall 4)

The Hall of the Natural History of Man when completed will consist of two parts, the first entitled "Introduction to Human and Comparative Anatomy," the second dealing with the physical characteristics of the Races of Man, Development, Growth and allied topics.

The first part begins by showing **Man in His Cosmic Aspect,** conceived as a living engine which derives its working capital of energy directly or indirectly from the energy of the sun stored up in plant and animal tissue. This energy is appropriated by man in food substances and distributed through the various anatomical systems.

In another exhibit the **Elements of the Locomotor Apparatus** are set forth. It is shown how red muscle fibres of the fish are combined into W-shaped muscle flakes, or myomeres.

Other exhibits deal with the anatomy of man as compared with lower vertebrates, following the chief organ systems and the locomotor apparatus.

The position of man among the vertebrates and the evidences of his evolution from lower types are illustrated by comparisons of skeletal structure in living and fossil types and by comparisons of his muscle system with lower forms, as well as by comparative embryology. An analysis of the nervous system, and the evolution of the human brain are dealt with and the functions of the brain are demonstrated.

The second part of the exhibit, on the right side of this hall, is devoted to **exhibits illustrating human biology.** It is planned to show the growth and development of the individual, the differentiation of man by constitutional and endocrine types, the racial classification of man, human genetics and race mixture, population problems and the technique of physical anthropology.

There have already been installed exhibits illustrating the growth and development of a human embryo, skeletal growth as shown in the head, and the variety of endocrine physical types. A series of full-size figures showing some of the major racial types has been placed in the central alcove.

Also in this alcove two charts are displayed. One illustrates the natural habitats of the various racial types exhibited. The other depicts the major population movements throughout the world since 1492.

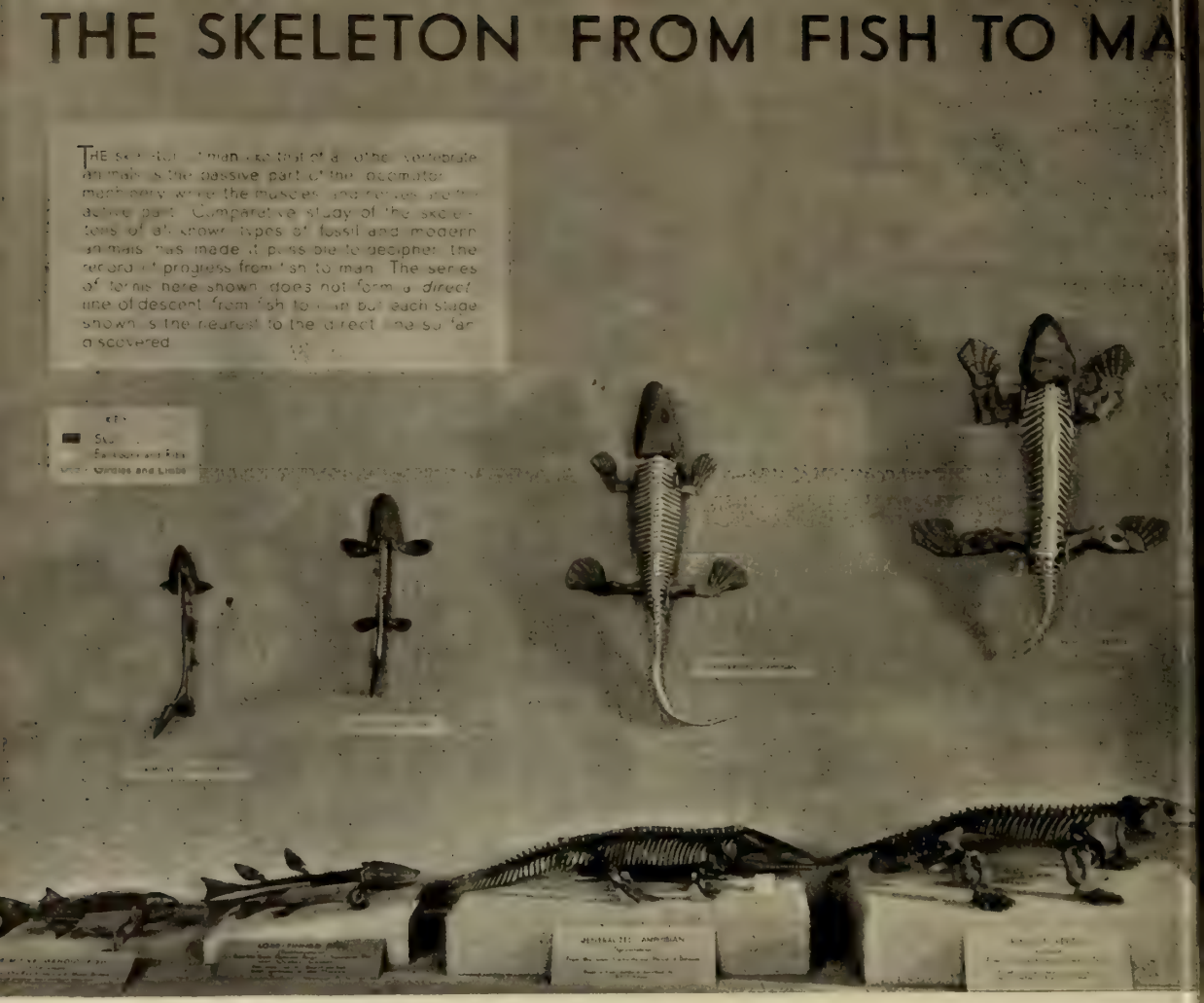
At the far end of this side of the hall will be found an exhibit on some of the more important endocrine functions.

The Skeleton from Fish to Man

(Index Plan, p. 18, Floor III, Hall 4)

The judgment of science is that our pre-human ancestors only reached the grade of humanity after millions of years of slow promotion from lower to higher grades of life.

Owing to the enormous number and variety of living forms in all ages and to the wholesale destruction of their skeletons by natural agencies, only about thirty of the fossil forms which we have dis-



THE FIRST FOUR STAGES FROM FISH TO MAN. (From water-living to land-living)

covered to date happen to lie in or near the direct line of ascent from fish to man. Nevertheless the story of the evolution of the skeleton from fish to man is already clear in its main outlines as shown by this exhibit prepared under the direction of Dr. William K. Gregory.

The **First Stage** represents the earliest true fishes by a model based on a fossil fish named *Cheirolepis* from the Old Red Sandstone (Devonian of Scotland). This fish, which breathed by gills in the normal fish way, must have looked somewhat like a trout, but its tail was more like that of a shark. The body moved forward in the water by a wriggling movement caused by the regularly arranged muscle flakes along either side of the body. The axis of the body was an elastic rod called the notochord (similar to that which appears in the embryonic stages of all higher vertebrates, including man). The fins were folds of skin, serving as keels and rudders.

The **Second Stage,** of Upper Devonian age, represents a long step in advance. It is based on a fossil fish named *Eusthenopteron,* from the Upper Devonian of Canada. This fish still had gills but there is some evidence that it also possessed an air-sac or lung. It had two pairs of paddles, corresponding to the fore and hind limbs respectively of four-footed animals.

The **Third Stage,** from the Carbonifer-



Stage 5 *Cynognathus* | Stage 6 *Opossum* | Stage 7 *Notharctus* | Stage 8 *Gibbon*

THE SECOND FOUR STAGES FROM FISH TO MAN. (From ground-dwelling to tree-dwelling)

ous age, represents the oldest known type of four-footed animals. The skeleton of the hands, feet and limbs is much more developed than in the previous stage. There are five digits on each of the hands and feet.

The **Fourth Stage** represents the primitive reptilian or lizard-like stage, from the Lower Permian of Texas. The skeleton on the whole is not greatly different from the preceding stage (except in detail) but the limbs were better developed.

The **Fifth Stage** represents an advanced mammal-like reptile *(Cynognathus)* from the Upper Triassic of South Africa. In this form the limbs were better adapted for running, and there are many features of the skull, backbone, and limbs that approach those of mammals.

For the **Sixth Stage** the skeleton of a modern opossum was used. It retains in the main the leading characters of the skeletons of the older fossil mammals. This form has five-toed grasping hands and feet, by means of which it climbs about in the trees. It has retained a relatively low type of skull, teeth, and brains.

In the **Seventh Stage** we come to *Notharctus,* a form that lies near the lower limits of the order of Primates. These animals were thoroughly adapted to life



Stage 9
Chimpanzee and Gorilla

Stage 10
Man

THE TWO FINAL STAGES FROM FISH TO MAN. (On the ground again, and attainment of erect posture)

in the trees but they had much larger eyes and bigger brains than any of the preceding stages.

The **Eighth Stage** is represented by the skeleton of the gibbon, an East Asiatic ape which is a tree-living descendant of the first family of the tail-less or man-like apes. When on the ground he is the only existing man-ape which normally walks on his hind legs. His skeleton begins to be almost human in many ways but his arms are excessively long.

The **Ninth Stage** is represented by our distant cousins the gorilla (below) and the chimpanzee (above). These apes retain the essential characters of the fossil apes of India and South Africa, some of which in turn approached quite near to the oldest known fossil men. The ape brain is much more developed than the brains of lower animals, and ape intelligence at times is almost human.

In the **Tenth Stage** we see that the human skeleton is built upon the same general plan as that of the chimpanzee, gorilla, and gibbon, but that in man the backbone, pelvis, and limbs are modified to enable him to walk on his hind legs and to use his forelegs as arms and hands rather than as supports. His brain is much larger and more highly developed than in the apes.



MAN AND THE APES. This exhibit illustrates the comparison of the skulls of man and the present-day apes, monkeys, and lemurs—all belonging to the great order Primates. The relationships of these groups are indicated by the branching lines of ascent from the inferred common stock

Family Tree of Man

In the **Hall of the Natural History of Man** (third floor) we see models of various skulls, ranging from the earliest Primates of the Eocene Period, through the monkeys and apes of the Miocene and Pliocene, to the subhuman and human races of the Pleistocene and Recent ages.

Early Races of Man

The exhibits in the central aisle of the **Hall of the Age of Man** deal mainly with the older races of mankind as shown by their fossil remains and by preserved fragments of their handiwork.

Men of the Stone Age. Here we see a skull-cast of Trinil, or Java "ape-man," and skeletal remains or casts representing Piltdown Man, Heidelberg Man, Neanderthal Man, and Cro-Magnon Man. An excellent series of sculptured restorations of these types, four of which are illustrated below, have been made by Dr. J. H. McGregor, and are generally considered as embodying the most recent scientific deductions as to the general appearance of these primitive races of mankind. The

RESTORATIONS OF HEAD AND SHOULDERS OF EARLY MAN. These restorations were made by Professor J. H. McGregor following scientific principles and utilizing the skull-remains of the various types as a starting point. They are as follows:

(1) Trinil Ape-Man
Pithecanthropus erectus

(2) Piltdown Man
Eoanthropus dawsoni

(3) Neanderthal Man
Homo neanderthalensis

(4) Cro-Magnon Man
Homo sapiens cro-magnonensis





CRO-MAGNON ARTISTS OF SOUTHERN FRANCE, at work in one of the limestone grottoes of the region. They are engaged in painting on the rough stone walls pictures of the woolly mammoths, which were then living

earliest of them takes man back at least to the lower Pleistocene, estimated at 1,000,000 years ago.

Weapons and implements of rough and polished stone and of bone are exhibited as evidence of the gradual up-building of human culture through the "rough stone" and "polished stone" ages of man's prehistoric periods. Reproductions of the cave paintings of Cro-Magnon man in France and Spain show the artistic ability of the early stock which first represents modern man in Europe.

A series of mural paintings by Charles R. Knight over the doorways of the Hall of the Age of Man give a vivid idea of the various races of early man as visualized by the artist in harmony with our best scientific knowledge.

The Hall of Prehistoric Cultures on the second floor of the Museum (Index Plan, p. 17, Floor II, Hall 6) is also devoted to exhibits of the early arts and industries of the European Cave Men and Lake Dwellers, as well as of North American prehistoric men.

STAG HUNTERS OF THE NEOLITHIC OR NEW STONE AGE. These men came into Europe after the climax of the glacial climate had passed. Their descendants apparently still exist in parts of Europe. This mural represents a family living on the shore of the Baltic. These people were the forerunners of later civilized man





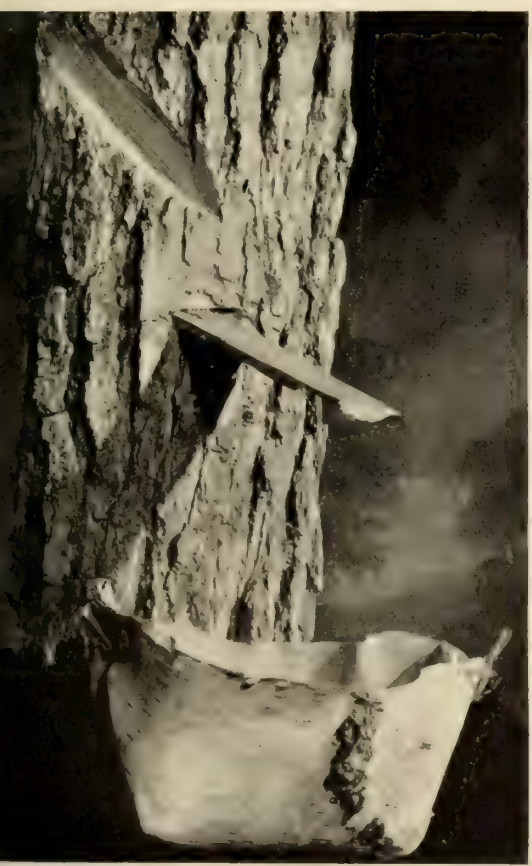
MAPLE SUGAR CAMP: a miniature group showing how the Indians in the sugar maple region engaged in this springtime activity. The sap was boiled in bark kettles. The dome-shaped house was used for storing the utensils when not in use

LIVING RACES OF MAN

North America

The Museum's exhibits on the life of the native peoples of North America occupy five halls on the first floor. The Indian exhibits radiate left and center from Memorial Hall, near the 77th Street entrance.

(Below) HOW the Indians gathered maple sugar



The Woodland Indians

(Index Plan, p. 16, Floor I, Hall 4)

Walking toward the left on entering the building, we meet first the Indians of New York and New England, and the successive exhibits are so arranged that you can imagine yourself traveling across the United States from east to west.

Although designated as the Eastern Woodlands Indian Hall (northeastern United States and Canada), the exhibits in this hall extend beyond these cultural and geographical limits. They include the Southeastern and Mackenzie culture areas, the former contiguous to the Eastern Woodlands on the south, the latter on the northwest. The whole of the Eastern Woodland area was in forest and extended westward from the Atlantic coast almost to the Mississippi River. Objects in the cases show that these Indians lived in the forest. The materials they used came from the forest, and this fact influenced their houses, tools, weapons, clothing, and ornaments, so that they are readily distinguished from those of other areas.

These forest Indians were primarily hunters and fishermen, but wild rice and maple sugar were staple foods. Agriculture was practiced where the climate permitted, and corn, beans, squash, tobacco, etc., were raised. (See miniature dioramas at north side of hall.) Their woodland environment led to various simple industries naturally dependent upon the raw materials that were at hand and adaptable to their daily needs.

Wood was used for canoes, mortars,



USE OF BIRCH BARK AMONG THE EASTERN INDIANS (From a miniature group in the Woodland Indians Hall)

spoons, bowls, dishes, houses, and wood splint baskets. Bark of various kinds was a favorite material. For example, the birchbark industry, as shown in the model illustrated above, is exemplified by containers and ornaments in many of the cases. Bark like that of the basswood tree was also shredded to make the fiber for weaving bags.

Skins were originally used for costumes, but cloth was often bought from white traders. Many wild plants and trees furnished fiber from which these Indians made good string and cord for making fish-nets and weaving bags. Every well-furnished home required mats for the floor and for sleeping, as shown in the group pictured below.

Climate influences the ways of life. In

MAKING CORN BREAD IN AN IROQUOIS HOUSE (From a miniature group)



this hall, the tribes represent a range from near-Arctic Canada to sub-tropical Florida. Their clothing varies from fur garments among the Dene and the Cree, to thin dresses of commercial cloth among the Seminole.

A number of miniature groups along the side walls and in the cases show tribal costume, housing, and industries. Especially interesting subjects are rock shelters, the making of rabbit-skin clothing, weaving with basswood fiber, making a false face, and the stages by which grains of corn are transformed into bread.

Travel was on foot. Dugout or bark canoes were used in summer where streams or lakes were available. Snowshoes were used in winter, and in the north the toboggan was common.

The dwellings of this area are of several forms. Among these are the long rectangular houses of the Iroquois covered with oak bark, the dome-shaped huts of Long Island and vicinity which were covered with mats and bundles of grass, and the familiar conical wigwam of the Ojibway covered with birchbark. The utensils are of pottery, wood or birchbark. Pottery was made by most of the Eastern tribes and seems to be associated with the practice of agriculture. The designs are incised, never painted. Bowls, trays, and spoons are made of wood and often decorated with animal carvings. The use of birchbark in the construction of light, portable household vessels is a particular trait of our Eastern Indians.

Examples of Indian inventions are canoes, maple sugar, tobacco pipes, cornhusk weaving, splint baskets, tump-line, wampum, la crosse game, netted snowshoes, toboggan, and water-drum.

A MANHATTAN INDIAN WOMAN COOKING IN A POTTERY BOWL (Group in Woodland Indians Hall). Not much is known of the Manhattan Indians except from traditions handed down by early settlers. Some remains of their clothing and implements are in existence as illustrated below



The Indians' history begins with the landing of white men. Many of the objects shown in the cases are historic, but others, such as the stone, bone, and shell objects found in the ground, are usually prehistoric. In the exhibits dealing with Manhattan and Staten Islands, from which the Indians were driven by the first settlers, we can exhibit nothing but pottery, stone, bone, and shell objects. These local relics will be found near the entrance to the hall. On the left are some pottery vessels and many small objects of stone and bone from Manhattan Island, Staten Island, Long Island, and Westchester County. Near by on the same side of the hall are collections obtained from living Indians of the coast region north and south of New York. These are the Penobscot and Passamaquoddy of Maine, the Micmac and Malecite of the lower provinces of Canada, and a few but rare objects from the Delaware who once occupied the vicinity of New York City and the State of New Jersey. The age and historical relations of these cultures are shown in a large label at the left of the entrance.

A family group of Micmac Indians, in a birchbark conical house, is shown half way down the hall.

On the opposite side are the Iroquois, whose league comprised the Mohawk, Seneca, Oneida, Onondaga, Cayuga, and later the Tuscarora. They dominated New York and much adjoining territory. The exhibits represent particularly the agriculture of the East, which was carried on with rude tools by the women.

In the farther end of the hall, on the left, are the collections from the Ojibway, Hiawatha's people, who lived mainly north of the Great Lakes. They had but little agriculture, living chiefly by hunting and fishing. Beyond the Ojibway are the Cree, who lived still farther north.

Opposite the Ojibway are the great Central Algonkin tribes, the Menomini and Sauk and Fox, who lived south and west of the Great Lakes. They gathered wild rice and hunted and fished, also practicing some agriculture.

In the southeastern portion of the United States, agriculture was highly developed. These tribes are represented by the Cherokee and Yuchi, who made pot-



A DAKOTA SIOUX WARRIOR (Model in Plains Indian Hall)



KOTA SIOUX WOMAN (Model in Plains Indian Hall)

tery, and by the Choctaw and Chitimacha, who made interesting baskets of cane. The Seminole of Florida have maintained an independent existence in the Everglades for nearly a century. Their prehistoric arts are illustrated in the table case. They excelled in polishing stones and working shell. (See the diorama on the north wall.)

Plains Indians

(Index Plan, p. 16, Floor I, Hall 6)

The keynote to Plains Indian life could be sounded by such terms as "tipi," "buffalo," "horse," and large decorated "pipes." The tipi and the pipe are especially conspicuous in the center of the hall.

The art of these Indians is highly original and popular. Painting upon skin is the usual method, but many designs in beadwork and quills are shown prominently in the hall.

Artists look upon the feather headdress of these Indians as the most beautiful type of headdress to be found anywhere in the world. With this and his highly decorated costume, the Plains Indian is colorful.

Indians of the Plains comprised the tribes living west of the Mississippi and east of the Rocky Mountains as far south as the valley of the Rio Grande and as far north as the Saskatchewan.

Occupying the greater part of the hall, beginning on the left, are the buffalo-hunting tribes: the Plains-Cree, Dakota, Crow, Blackfoot, Gros Ventre, Arapaho and Cheyenne. These tribes did not practice agriculture but depended almost entirely on the buffalo. Buffalo flesh was their chief food, and of buffalo skin they made their garments. In some cases a buffalo paunch was used for cooking, and buffalo horns were made into various implements of industry and war. The spirit of the buffalo was considered a powerful ally and invoked to cure sickness, to ward off evil, and to give aid in the hunt. Wherever the buffalo herds led the way, the more nomadic Plains tribes moved their tipis and followed. With the extermination of the buffalo the entire life of the Plains Indians was revolutionized.

On the right, near the entrance, are the



LEACHING ACORN MEAL AMONG THE HUPA INDIANS OF CALIFORNIA. Water is placed in a basket and brought to the required temperature with heated stones

village tribes of the Plains: the Mandan, with whom Lewis and Clark passed the winter of 1804-1805; the Hidasta, who now live with them; and the Omaha, Kansa, Iowa, and Pawnee. All these tribes raised corn and lived in earth-covered houses of considerable size. A small model of one of these houses stands near the exhibits.

In the center of this hall is a Blackfoot Indian tipi with paintings of otters on the sides, representing a vision of the owner. This tipi has been fitted up to show the home life of a typical buffalo-hunting Indian.

There were numerous soldier societies among the Plains Indians which included practically all the adult males. Each society had a special dance and special costumes. (See the Arapaho cases for costumes of dancers.) There were other dances connected with tribal religious ceremonials, the best known and most important of which is the Sun Dance, illustrated by a model at the left of the tipi. The Sun Dance was held annually in the early summer in fulfilment of a vow made during the preceding winter by some member of the tribe who wished a sick relative to recover. The dance involved self-torture, great physical endurance and a fast lasting three days.

In the center of the hall is a genuine medicine pipe, held in awe by the Indians and dearly parted with; also the contents of a medicine-pipe bundle. The contents of another medicine bundle, belonging to a leading man of the Blackfoot tribe (medicine-man), together with the headdress which he wore in ceremonies, are in



(Above) BLACKFOOT WOMAN AND CHILD TRAVELING WITH TRAVOIS, which are attached to the horse and dog and are dragged behind them. A primitive method of transportation. From a miniature group in the series of models showing methods of transportation. In the Eastern Woodlands Indian Hall

A BULL BOAT OR CORACLE OF THE HIDATSA INDIANS OF NORTH DAKOTA was made by stretching skins over a basin-shaped wooden frame. It was used for fording streams





(Above) APACHE WOMAN BUILDING FRAMEWORK OF A HOUSE to be covered with thatch and rushes

A NAVAJO MEDICINE LODGE. For the celebration of the Navajo Night Chant a special house is erected. The medicine man is laying down an elaborate ceremonial sand-painting. Group in Southwest Indian Hall



a case near the tower. Other remarkable bundles, particularly the skull bundle, are in the Pawnee case, on the north wall.

The Plains Indians are noted for their picture-writing on skins and for their quillwork, which was superseded by beadwork when glass beads became available in historical times. They have a highly developed decorative art in which simple geometric designs are the elements of composition, this being one of the most interesting features of their art. (See Dakota case and Guide Leaflet No. 50, also Handbook No. 1, North American Indians of the Plains.)

The Indians of the Southwest

(Index Plan, p. 16, Floor I, Hall 8)

This region is famous for two reasons: the picturesque living Indian tribes, and the large number of ruins built by prehistoric Indians. Since many of the latter are placed upon high rocks or in the walls of canyons, they are spoken of as Cliff Dwellings.

This hall presents collections from both the prehistoric and the living Indians of the Southwest. On the right are the nomadic tribes: the Apache, Navajo, Pima, Papago, and Havasupai. A life-size exhibit, the first of a series along the right-hand wall, shows the home life of the San Carlos Apache. Next is a larger group showing a Navajo hogan in Canyon de Chelly, and the Night Chant ceremony. The painted background in this group gives a view of the canyon, and in a cave of its walls, one may see the famous White House ruins.

In near-by cases, Navajo silverwork and blankets are exhibited. The Navajos are the modern blanket makers. With simple implements and looms, they card, spin, and weave the wool of the sheep they raise. This art has arisen since the coming of the Spaniards and it is known to have passed through several stages in the last sixty years. Some of the older types of blankets here shown contain yarn which was obtained by cutting or raveling from imported flannels, called in Spanish "bayeta," from which these blankets receive their name. These are either bright red or old rose in color, resulting from cochineal dye. Several blankets are made of yarn bought ready dyed from traders and are called Germantowns. The greater number, however, are made of yarn of native spinning, dyed with native vegetable and mineral dyes.

The Navajo are a large and widely scattered tribe. During the winter they occupy log houses, but in milder weather they camp in the slight shelter of a cliff or windbreak and shade made of brush. They live by raising corn in the moist valleys, and on the flesh of their numerous flocks of sheep.

The Western Apache live along the upper portion of the Gila and Salt rivers, where they practice agriculture, gather natural products, and hunt. Indians related to these, under Geronimo, raided the settlements of southern Arizona and northern Mexico and evaded our troops for years. They live in grass-thatched houses or in the open under the shade of flat-topped, open-sided shelters.

The Eastern Apache lived in buffalo skin tipis. They went far out on the plains in search of the buffalo herds, avoiding, if possible, the Plains tribes, but fighting them with vigor when necessary. In dress and outward life they resemble the Plains Indians, but in their myths and ceremonies they are like their Southwestern relatives and neighbors.

In the first alcove to the right of the entrance is a basketry exhibit showing the types of baskets and the materials, tools, and techniques employed by the Southwestern tribes. This exhibit is in contrast with the corresponding case of pottery on the opposite side. Not the environment, but social habits, caused one people to develop pottery and the other to make the easily transported and not easily breakable baskets. (See Handbook No. 2, Indians of the Southwest.)

At the left of the hall, as we enter, are exhibits for the modern village Indians — first types of pottery from San Ildefonso, Laguna, Santo Domingo, Zuni, and Hopi.

The Pueblo Indians live in large community houses, built of stone or adobe, often with several receding stories. They depend chiefly upon agriculture for their food, make a great variety of pottery, and have many elaborate religious ceremonies. The nomadic peoples live in tipis or small brush and thatched houses



MODEL OF A KWAKIUTL HOUSE (In the North Pacific Hall). The Kwakiutl Indians live on Vancouver Island, and on the mainland to the north. They build their rectangular houses of split cedar planks on a framework of heavy posts and beams. The front is decorated with fantastic designs and a totem pole near the house door is carved with grotesque figures as a coat of arms of the owner

(Right) CEREMONIAL RATTLE OF THE HAIDA INDIANS



(Below) TLINGIT BASKETS. Twined basketry made by the Tlingit Indians of the British Columbian sea coast. Spruce-root fibers are used for both warp and woof





which are moved or deserted when they are forced to seek the wild game and wild vegetable products which furnish much of their food. They make baskets for household purposes which are more easily transported than vessels of clay. In the hall are models of the pueblos of Taos and Acoma, of prehistoric cliff-dwellings, and of the houses used by the Navajo.

The inhabitants of Zuni are believed to be the descendants of the first people seen by the Spaniards in 1540. Their former villages, many of which now are in ruins, were probably the "Seven Cities of Cibola," for which de Coronado was searching at that time. Although there were missionaries among them for about three centuries, they have retained many of their own religious ceremonies. Many ceremonial objects as well as those pertaining to everyday life are shown in this alcove.

In the Hopi section are costumes, masks, images, and basketry plaques used in their ceremonies. Their best known ceremony is the Snake Dance, the performance of which is supposed to increase rainfall and the crops. Some of the regalia worn for the Snake Dance are shown, as well as a small model of a single phase of the ceremony. On the right side of the hall, next to the Navajo group, is a representation of Hopi life.

In the center of the hall, as well as in the farther half of the left side, are special exhibits for the prehistoric Indians of the Southwest. Near the center is an exhibit showing how many prehistoric ruins have been dated by the tree-ring method. A chart at the entrance to the hall gives the successive culture periods for the Southwest, beginning with early Basket Maker and ending with the modern Pueblo villages. Typical objects made by the Basket Makers are shown in small cases in the center of the hall and in upright cases to the left.

Two of the most famous prehistoric Southwestern ruins are Bonito and Aztec. A model of the latter stands in the center, and near the entrance is an exhibit of turquoise from Pueblo Bonito. Other collections from these two ruins are shown in cases at the left of the hall. One contains a remarkable collection of pottery from Pueblo Bonito. Similar black-on-white wares with very elaborate and

HOUSE POST FROM VANCOUVER ISLAND

splendidly executed designs, shown in adjacent cases, are from Rio Tularosa, and in part from cliff-dwellings. In another case will be found material gathered by the Museum expedition which explored the Galisteo Valley, New Mexico. (See Guide Leaflet No. 73, *Pottery of the Southwest Indians.*

At the farther end of the hall, at the right, is an exhibit from the prehistoric Indians of California. (See Guide Leaflet No. 55, *Basketry Designs of the Mission Indians.*)

Indians of the North Pacific Coast

(Index Plan, p. 16, Floor I, Hall 1)

The Jesup North Pacific Hall is devoted to the Indians living in the heavily forested and mountainous coastal belt extending from the Columbia River in Washington to Mt. St. Elias in southern Alaska as well as on the offshore islands. They are the most skilful wood workers on the American continent, as demonstrated here by the models of their houses; their intricately carved and painted totem, house, and grave posts; their ceremonial masks, boxes, implements, and tools. Paralleling their dependence on their forest environment for housing, clothing, and utensils, was their dependence upon the products of the sea for food. Travel and transportation were mainly by water, for which canoes, like the large Haida war canoe in the center of this hall, were built by skillfully hollowing out giant cedar logs.

Except for two tribes, the Shushwap and Thompson, who live in the interior of British Columbia, the exhibits are arranged in the order in which the several tribes are encountered in traveling from south to north along the coast of Washington, British Columbia, and Alaska. On the right side of the hall are the Bella Coola, Tsimshian, Haida; on the left, the Nootka, Kwakiutl, Tlingit.

The murals of Will S. Taylor illustrate not only the industries, religious and social life of these Indians, but also their heavily forested and fog- and rain-drenched environment. The murals on the right side are devoted to ceremonial and religious life, on the left to daily life and industries. Over the entrance are shown games, and at the farther end of



CARVED WOODEN FIGURE made by the Quinault Indians inhabiting the northwestern coast of the State of Washington



ESKIMO WOMAN FISHING THROUGH THE ICE (Group in the Eskimo Hall)

the hall is depicted the return of a victorious war party.

No less conspicuous than the woodcarving art of the Northwest Coast Indians is their skill in weaving in mountain goat wool and shredded bark and in making baskets. Notice in this connection the Chilkat ceremonial blankets a little over halfway along the hall, on the left, and the Tlingit baskets at the end. These Indians have likewise distinguished themselves in the carving of stone, bone, and ivory, examples of which are shown for the various tribal groups.

Outstanding perhaps is the wealth of decoration observable on all their products. The typical grotesque art motives, based on the distortion of animal forms,

are found in equal abundance on utilitarian and ceremonial objects.

Eskimo Corridor

(Index Plan, p. 16, Floor I, Hall 7a)

The Eskimos are frequently cited as the primitive people who have achieved the most complete adjustment to their environment. They inhabit the northern shores and adjacent islands of North America, from easternmost Siberia and the Aleutians to East Greenland and Labrador. All these Eskimos, who differ somewhat in details of culture according to locality, are represented here, though not with equal completeness.

Contact with the white man has changed the Eskimo's way of life to greater or lesser extent, but he continues to use many of his traditional tools, implements, and distinctive articles of fur clothing. The Eskimos are hunters and fishermen. In summer they hunt the caribou, musk ox, and birds, often inland. Their dwellings at this season are tent-like frames covered with deer or seal skin. In winter they hunt sea mammals, especially seals. Their winter houses are of stone built over shallow excavations and covered with earth. The familiar snow-house is the traditional winter dwelling of certain tribes but is unknown in Alaska and most of Greenland. Models on exhibit show how the snowhouse is built. The Eskimos are skilled in the making of fur clothing and skin boats. The ingenious implements they fashion of wood, bone, and ivory are frequently decorated with naturalistic incised designs.

Many of the objects shown here are from the collections made by the Peary, Comer, MacMillan, and Stefansson-Anderson expeditions.

Near the entrance of the corridor is an Eskimo woman fishing through the ice. She has formed a windbreak with blocks of ice. The fishing rod and hook and the long ladle are made of bone, and with this latter she keeps the water in the hole from freezing over while she is fishing. In another case will be found an Eskimo woman cooking in the interior of a snow hut that is lined with seal skin. She is using a stone lamp filled with seal oil, which feeds the flame over which the meal is being prepared.

Central America

(Index Plan, p. 17, Floor II, Halls 2a and 4)

Near the west stairway on the second floor we enter a corridor and hall devoted to the ancient civilizations of Mexico and Central America. Along the walls of the stairway are casts of some of the finest stone monuments from the Maya cities of Central America, and the corridor alcove contains pottery and stone objects from Costa Rica. In the central portion of the main hall are three illustrated maps, one showing several typical landscapes in Middle America and the other two the distribution of pottery types and architectural forms. Farther on are a number of cases devoted to the finest objects in the collection, which well illustrate the great artistic achievements of the Middle American civilizations.

The far end of the hall is devoted to the Maya culture. The right side shows the known cultures of Central Mexico, from the earliest to the latest, and the left side deals with Northern Mexico, the Mexican Period of Yucatan, the Zapatec culture of Oaxaca, and Aztec sculpture.

Peoples and Time: The history of ancient Middle America is little known. Contemporary archaeological opinion gives the following rough dates: —

10,000 B.C.—200 B.C. Period of Population and Settlement. No remains yet identified.

200 B.C.—500 A.D. Early Cultures, including growth of techniques of farming, weaving, ceramics, stonework, and establishment of permanent villages. Some persist until the Spanish Conquest.

500 A.D.—1000 A.D. Ritualized Civilizations with Temple Cult, Polytheism and Sacred Calendar, like Maya of Guatemala, Zapotec of Oaxaca, Olmec of Vera Cruz, Teotihuacan of Valley of Mexico.

1000 A.D.—1200 A.D. Period of Unrest and Migration, Chichimec Period in Valley of Mexico, Mexican invasion in Yucatan.

1200 A.D.-1519 A.D. Domination of Mexican Peoples. Mexican Period in Yucatan, Mixtec Period in Oaxaca, Aztec Period in Valley of Mexico.

There are specimens shown in the hall whose makers are absolutely unknown, but whose style is distinctive. Conceiv-

ably in time we may be able to assign them to the speakers of some one of those fifty languages recorded for Mexico, a fact which in itself indicates that in Middle America there were tribes not empires.

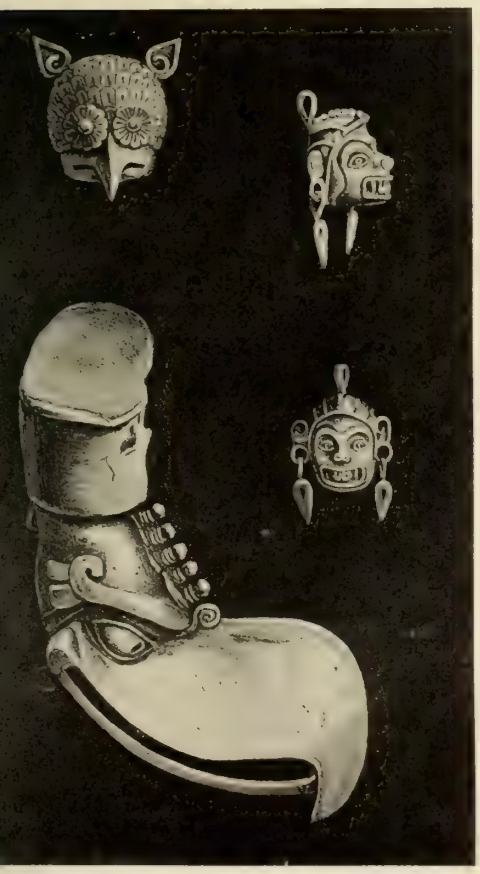
Nature of Objects: The majority of objects shown in the Hall are made of pottery, stone, bone, shell, and metal, because these substances best resist the destructive action of time and weather and are preserved through the centuries. Therefore, the wooden drums in the Aztec case and the obsidian mirror with the wooden frame are great treasures, since only a handful of examples of the woodcarver's art survived the Conquest.

Architecture: The varied and imposing temple architecture of Middle America may be estimated by the models distributed throughout the hall. The Maya buildings of which we have examples ranging through the span of their history show how a sculptured platform evolved into one supporting a massive shrine, and how that in turn developed into temples and priests' quarters. Yet the architecture of the Zapotec, Toltec, and Aztec is hardly less imposing, and the cast of a Serpent Column from Chichen Itza brings vividly home the tremendous scale of these Indian temples.



AZTEC PICTURE WRITING recording the last of the "New Fire Ceremonies" before the Spanish Conquest in 1519. It also represents an eclipse of the sun, an earthquake, and the drowning of two thousand warriors on their way to make war on the people of Southern Mexico

Sculpture: It is in sculpture that we may gauge best the tremendous attainments of the ancient peoples of Middle America. The polytheistic religion required many images depicted in a great variety of forms human, animal, and grotesque. The casts of Maya stelae from Quirigua indicate that the native sense of design could function in terms of an enormous mass. The intricate monuments from Copan likewise show how skillful a mass sculpture can be. Equally



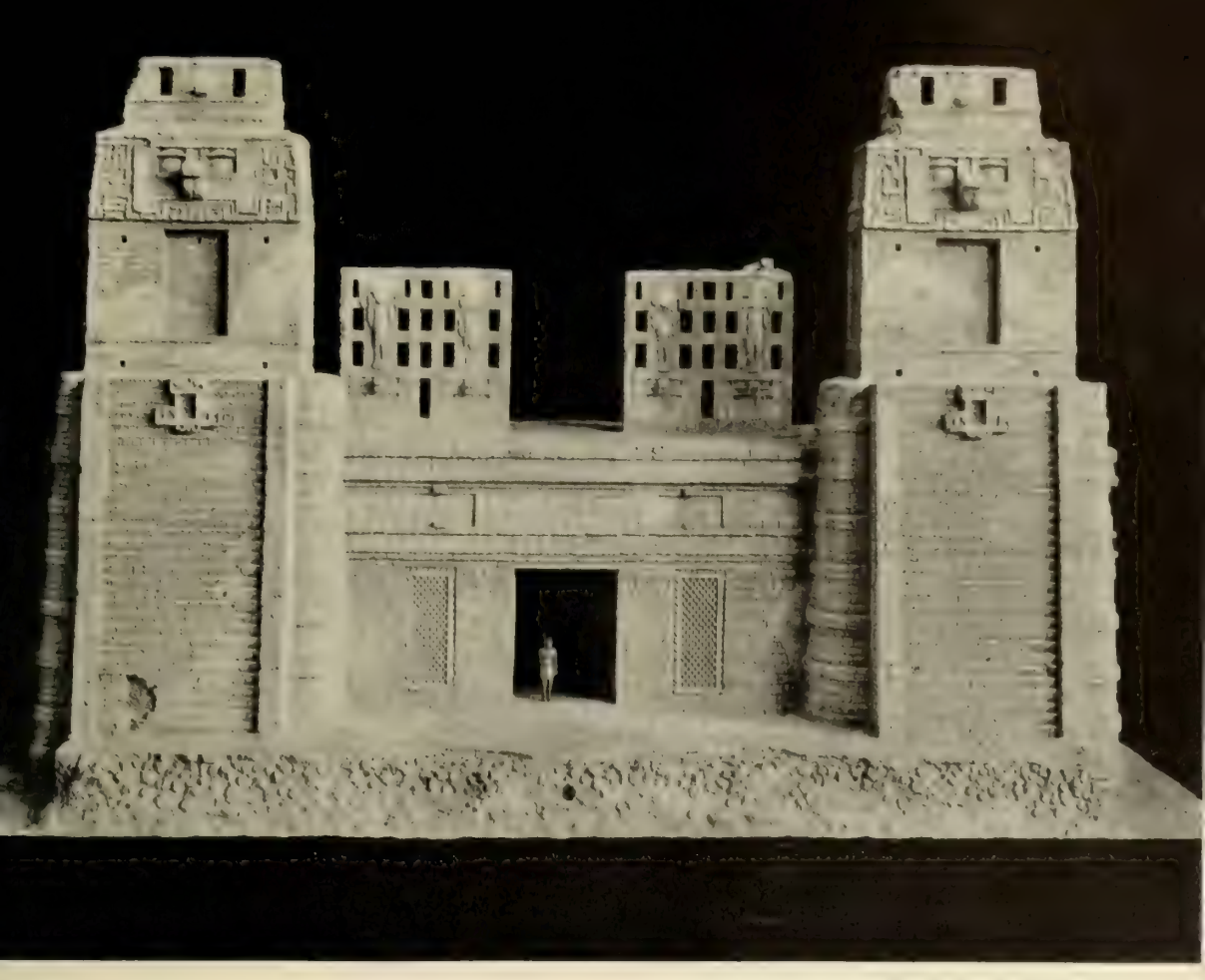
GOLD OBJECTS FROM
MEXICO AND CENTRAL AMERICA

important are the casts from the southwest coast of Guatemala ranged along the stair to the first floor. Yet there is an abundance of original material, which includes for the Maya some of the cream of the Copan style as well as original examples from Yucatan collected by the famous traveller, Stephens, a century ago. The abilities of the Aztec are displayed both in casts and original examples, which cannot be duplicated in this country. The work of the Totonac and Olmec, in the form of masks and small figures including jades, is thought by various authorities to be the best produced in Indian America, while the vigorous barbarity of the Geutar carving of Costa Rica is worthy of attention. A series from Oaxaca shows the laborious methods of carving stone with stone, since no metal tools hard enough for this purpose were developed by the Indians.

The figures in baked clay are worthy of considerable attention, since the Middle Americans developed this type of work into a fine art. Especially interesting are the historical series of figurines from the Early Culture and Teotihuacan horizons. These show the change in styles in two cultures, over a period of nearly a thousand years. The most notable clay sculpture is the life size warrior of the Chichimec period of the Valley of Mexico. However, for sheer vigor and vitality the large clay figures from Western Mexico are preeminent. A profound grasp of realistic appreciation of human features is displayed by the Vera Cruz exhibit of clay heads, laughing ones from the Totonac area, more serious ones from the



A PRIEST MAKING AN OFFERING: a cast of a Maya relief sculpture from Jonuta, Tabasco, Mexico. The original of this cast is in the National Museum of Mexico and is one of the finest examples of the Palenque style of Maya sculpture. This piece dates from the Maya Great Period in the centuries immediately preceding the year 1,000



MODEL OF A MAYA TEMPLE: a miniature replica of the temple at Rio Bec in the eastern part of the state of Campeche, Mexico

Tuxtla region. A culmination of ceremonial requirements is to be seen in the funerary urns from Oaxaca, where a great sense of design mitigates the grotesque forms employed.

Writing: Examples of the methods of writing used in Middle America are found in different parts of the hall. The simple pictographic style of the Aztec and Mixtec are represented by original paintings on cloth and by skillful reproductions. A post-Conquest land map and genealogical tree from Tlaxcala throws much light on dress and costume fifty years after the Conquest. The Zapotec and Maya writing was expressed by highly conventionalized signs. On the Maya casts long inscriptions relating to the dates of astronomical phenomena may be found. Aztec writing can be read, Maya writing partly deciphered.

Jewelry: Certain cases in the hall show priceless examples of Middle American jewelry. Jade was the substance most highly prized, and there are several local styles of working it. The American variety of jadeite and nephrite is distinct from the Asiatic type. Especially important are the Zapotec and Olmec collections, which include two of the finest specimens in the world. Gold was esteemed only as an easily malleable metal, but the workmanship on the Mexican pieces and the design of the Costa Rican



FIGURE OF A GOD. MAYA CULTURE. Limestone sculpture from Copan, Honduras. This is one of the finest examples of Maya sculpture in the round, showing how perfectly the Maya represented their physical type, and how beautifully they could express their art without the use of metal tools of any kind. Around the tenth century



MOCIUTLXOCHITL, THE GOD OF GAMES AND FLOWERS. A fine example of Mexican terra cotta pottery dating from about 1400 A. D.

ornaments attest again to the high level of Indian civilization.

Metals and Precious Stones: Silver is very rare, owing to the difficulty of extracting the ore, but copper was used in late times for tools and ornaments. Mirrors of iron pyrites used in their matrix and as a mosaic show an interesting utilization of this mineral. Obsidian or volcanic glass, commonly used for tools, was wrought into mirrors and ornaments with the simplest abrasives. Rock crystal, amethyst, moonstone, opal, jasper, and porphyry were other stones valued and worked as ornaments by these people.

Pottery: The commonest product recovered by archaeology is pottery, and the halls are full of vessels recovered from graves and ceremonial deposits. These vessels were not made on a wheel, and building up the pots with strips of clay brings about a squat appearance to our eyes. However, the variety of shape and design shows how each tribe or community had its own styles. Notable techniques are the vitreous ware from Salvador and the plaster cloissonné from Jalisco. Note also the common use of lost-color or batik decoration in Jalisco and Costa Rica. Vessels of huge size were

AND DOG *(Below)*. This little pair of clay figures from Colima, Mexico, shows the vitality of western Mexican art



sometimes made, like the Toltec vessels from Azcapotzalco. Even the earliest forms from the early cultures of the Valley of Mexico reveal a development of technique and style that indicates long years of experimentation. Few regions in the world can show such a wealth of form and ornament as Middle America.

Design: The textile art was important in Middle America but time and weather have destroyed almost all of it. However, hints are given by the ancient picture writings and the use of textile designs on pottery. The art is old and cotton has been recovered from the earliest levels in the Valley of Mexico. Examination of the designs on the Puebla pottery, on the West Mexican figurines, and on the dress of the figures on the Maya stelae will show how skilled these people were. In various cases the clay weights for spindles are exhibited, many of which are beautifully carved and polished. The size and weight seem to be gauged in some cases to the fineness of the thread.

Musical Instruments: Music was not highly developed in ancient Middle America, but many examples of flutes, whistles, shell trumpets and rattle bones attest to an interest in tone and rhythm. Most notable are the Aztec two toned drums which give forth very pleasing notes. A pottery whistling jar in the form of a rain god is one of the outstanding pieces in the Salvador collection.

Tools: The chief tools of the ancient Middle Americans were made of stone, bone and wood. Copper tools were only sporadically employed and in late times at that. The great wonder of Middle American civilization is that with these simple elements and without knowledge of the wheel or draft animals, these people were able to achieve an imposing culture comparable to the great civilizations of the Old World, whose technical basis was so much more highly developed.



THE GOD XIPE, LIFE-SIZE, in terra cotta. Worshipped by the Central Mexicans as the God of the Flayed, Xipe is shown here wearing a human skin. When the skin was fresh it was tied on the God. As it dried it wrinkled, and the wrinkles formed the scales. This practice flourished in Central Mexico about the year 1200



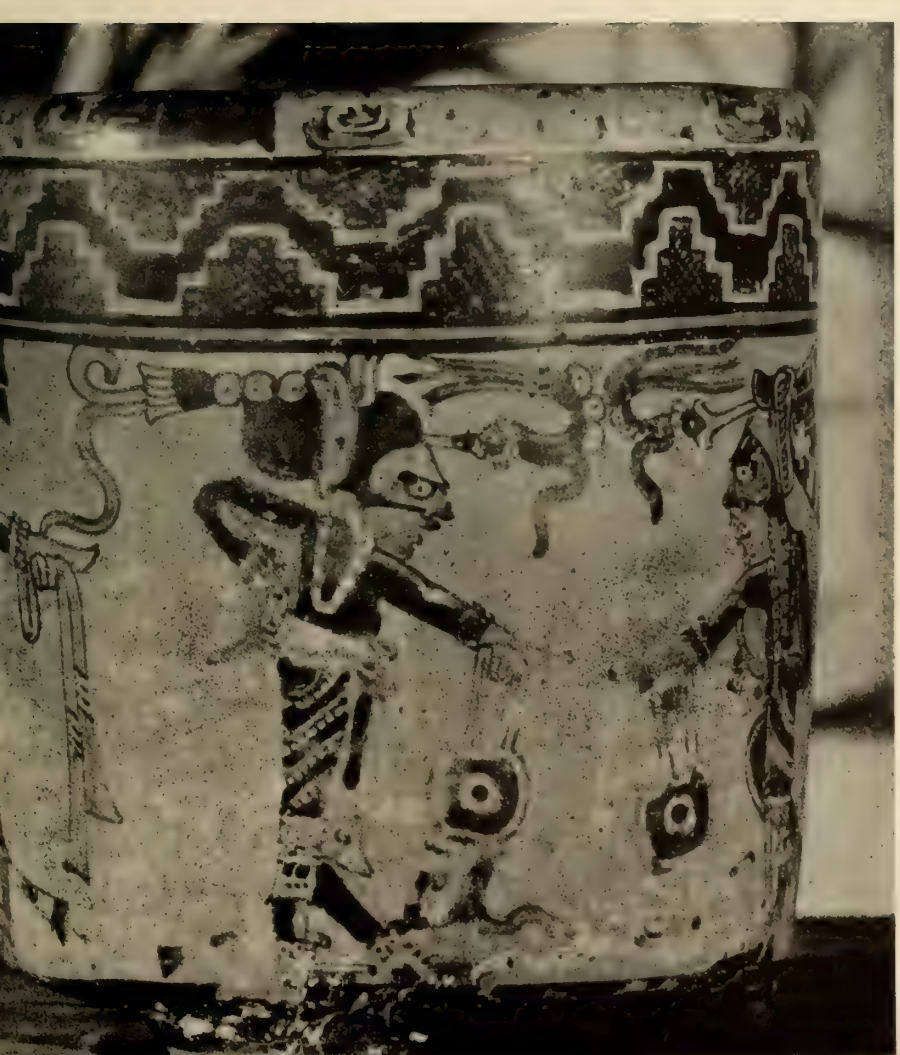
CORN GODDESS OF THE ANCIENT AZTECS. This figure from Ixtapalapa, Mexico, is carved in black basalt. It is an outstanding example of Aztec art showing great naturalistic skill in presentation. (Fifteenth century)



FIGURE OF A SEATED WOMAN: a splendid example of clay modeling from western Mexico, illustrating the remarkable ability of these ancient sculptors in depicting form and expression



LAUGHING CLAY HEAD. An example showing conscious humor. Clay heads of this type are said to be parts of complete figures. They come from central Vera Cruz. Nearly all the figures are laughing or smiling in a very contagious manner



MAYA VASE WITH FIGURE PAINTING. From San Jacinto, Salvador. Not only does it illustrate great skill in depicting attitudes, but seems to indicate a remarkable sense of humor in the artists

South America

(Index Plan, p. 17, Floor II, Hall 8)

This hall contains Indian exhibits from all the South American countries except Paraguay and Uruguay. The largest portion of these illustrate the prehistory of the peoples of Peru and Bolivia and are arranged in the front of the hall.

Unlike the ancient peoples of Mexico and Central America, the Peruvians had no written language. They were tillers of the soil and raised maize, potatoes, oca, quinua, beans, coca, and cotton. They domesticated the llama, which was used as a beast of burden. They excelled in the manufacture and decoration of pottery vessels, in metal work, and in textile fabrics.

Their gold and silver objects, such as beads, cups, pins, plates, and ear ornaments, show a high degree of skill in the beating, soldering, and casting of metals.

In weaving, the Peruvians were perhaps preeminent among prehistoric peoples of the world, many of their textiles exhibited here being unsurpassed at the present day. The materials used were cotton and the wool of the llama, alpaca, and vicuna. In the cases near the entrance are examples of these textiles and the fibers, spindles, thread, looms and other equipment used in their manufacture.

On the right side of the hall are col-

MUSICAL WIND INSTRUMENTS OF ANCIENT PERU. The wind instruments of the ancient inhabitants of Peru, as illustrated below, included the panpipe or syrinx shown in the center; resonator whistles *(left);* trumpets of clay and wood; and a great variety of simple whistles. The pottery figure at lower left shows how the panpipe was played





POTTERY OF THE EARLY CHIMU PERIOD. A warrior in full regalia is depicted on the vessel at the left. In his right hand he holds a mace; in his left, a shield, spear thrower, and javelins. The central piece is a "portrait" jar. The vessel at the right shows a hand to hand combat between mythical beings

lections from important localities in Peru, followed by exhibits from Ecuador, Colombia, Venezuela, Brazil, and Panama. In case 57, near the center of the hall, selected examples of pottery show the different forms and decorations which distinguish the various important cultures of Peru and Bolivia. As far as our present knowledge permits, the changes which occurred in the course of time are also indicated. Each of these cultures is shown in greater detail in individual cases. Outstanding is the beautiful work of the Nazca people in cases to the left of the entrance. In special exhibits are grouped such things as musical instruments, whistling water jars, examples of intentionally deformed human heads and trephined skulls showing the successful practice of a delicate surgical operation by the ancient



POTTERY OF EARLY NAZCA PERIOD. The Valley of Nazca was the center of one of the earliest highly developed cultures in Peru. It dates from the beginning of the Christian Era. The two jars at the left show conventional representations of the feline-monster deity

Peruvians. Much of our knowledge of their daily life we owe to a fortunate combination of climatic conditions and tribal customs. Along the coast of Peru, where the extreme dryness of the climate and nitrous character of the soil have preserved perishable materials for centuries, are more extensive burial places than anywhere else in America. Countless thousands of bodies were interred with such things as had been most useful and prized during life or were considered to be most serviceable in a future life. Examples of these mummy bundles are displayed, and it was from such as these that many objects in the hall were secured.

The mummy in the case at the west side of the room was found in a copper mine at Chuquicamata, Chile. The body is that of an Indian miner who was killed by the falling in of rocks and earth while engaged in getting out the copper ore (atacamite) used by the Indians in making implements and ornaments in prehistoric times. The tissues of the body have been preserved by copper salts with which they are impregnated. The implements he was using at the time of his death are shown beside him in the case.

Much more primitive than any of the prehistoric peoples just mentioned were the nomadic hunters and fishermen who inhabited the southern end of the continent and the adjacent islands. Their story from the time when they hunted

PREHISTORIC DOUBLE CLOTH. This is the finest example of ancient South American technique in weaving in the Museum collection. The double cloth is woven on two looms, one above the other, arranged so that the warps are parallel. Warps and wefts of contrasting colors are used in each loom





PERUVIAN EMBROIDERED SHAWL. The designs in polychrome chain stitch embroidery depict mythical warrior figures. Weaving was an outstanding artistic and technical achievement of the ancient Peruvian civilizations. The thread was hand-spun from cotton and wool and the fineness has never been surpassed. The textiles, from 500 to 2000 years old, have, for the most part, been preserved as mummy wrappings in the graves of the dry desert of Peru

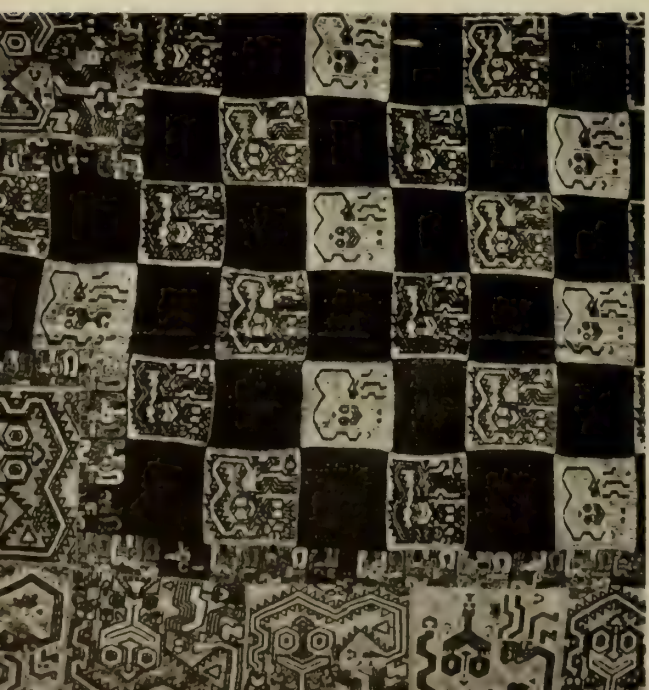


A PERUVIAN WOMAN'S WORK BASKET. Containing spindles, bobbins, carded fibre, and other materials for spinning and weaving

the extinct native American horses and ground sloths was recovered from caves and shellmounds. The simple tools and weapons which they used are arranged chronologically in a case in the rear of the hall. Near by are examples of the equipment of the various tribes surviving in the same region at the present time.

In neighboring cases are exhibits for other living Indians of South America. As there are a great many distinct tribes, sometimes living in widely different geographical areas, the collection is far from complete. An example of native life in the tropical rain forest of northeastern Peru is shown in a miniature group of the Chama Indians. They raise plantains and cassava and hunt small game, so their equipment is naturally specialized for these occupations.

(Below) AN EXAMPLE OF SOUTH AMERICAN EMBROIDERY. This elaborate fabric is a Paracas type solid polychrome embroidery



(Below) A PERUVIAN TAPESTRY. An excellent tapestry from Pachacamac, Peru, with slits left open between color areas as part of the design





ASTER ISLAND STATUE. Easter Island in e South Pacific is famous for the immense one statues found there. from one of which Museum expedition made the cast illustrated above

The Pacific

(Index Plan, p. 19, Floor IV, Halls 6 and 8)

Two halls are devoted to the Islands in the Pacific Ocean. The first contains collections from **Polynesia, Micronesia,** and **Melanesia.** The second is principally an exhibit for the natives of the **Philippine Islands, Java,** and **Borneo.** However, the collections from **New Zealand** extend into this hall.

The conspicuous objects in these halls are as follows: a statue from Easter Island; life-sized models, showing the Tahitian fire-walking, grating of coconut, etc.; a collection of tattooed heads from New Zealand; and a tree-house from the Philippines.

South Pacific Hall

On entering the South Pacific Hall (Floor IV, Hall 6) beyond the Hall of Minerals, the visitor faces a huge monolithic figure. This is a cast of one of the famous images found on Easter Island and was brought back in 1935 by the Templeton Crocker Expedition. Statues such as these, representing departed chieftains, were found set up on stone platforms all along the coast of Easter Island. Circular stone mats of red tufa formerly completed the figure.

Directly in the center of the hall is a

MINIATURE MODEL OF A SOUTH SEA ISLAND CANOE. The Polynesians make canoes hollowed out of tree trunks. An outrigger on one side keeps them from capsizing easily





TAHITIAN KAVA-BREWER AND ROOF-MAKER. The Tahitian woman, at the left, is preparing a stimulant from the roots of a species of pepper. The beverage is known as ava in Tahiti but is identical with kava of other islands. The woman to the right is manufacturing roofing from pandanus leaves in an elaborate form often employed in Tahiti. Life size figures cast in the Museum from Tahitian fire-walkers who once visited New York City

Tahitian priest taking part in the fire-walking ceremony, in which the participants walk over heated boulders of lava. On each side is a group showing natives engaged in typical activities, — grating coconut, preparing kava, or plaiting *Pandanus*.

One of the exhibits that was removed from the Museum for safe-keeping for the duration of the war is a fine Hawaiian

TAHITIAN FIRE-MAKER AND COCONUT GRATER. The old way to make fire in Tahiti was to rub a blunt-pointed stick in a groove made in another until the dust became ignited. The natives produced fire within a few minutes. In preparing grated coconut the Tahitians sit on a stool which has a blade projecting in front. This blade is used for grating the white inside part of the coconut





POLYNESIAN BARK CLOTH OR TAPA. This cloth was made from the inner bark of the paper-mulberry tree which is steeped in water, thinned out with a shell scraper, and pounded on a board with a mallet. Designs may be painted on the cloth free-hand, but more frequently they are printed from wooden stamps

feather capė, such as was formerly worn by the highest ranks of the Hawaiian society. Red and yellow honeysucker feathers completely hide the netted twine foundation. The value of these garments was proportionate to the enormous labor expended on their manufacture.

The hall is roughly divided into two main sections. In the first half are exhibited the collections from Polynesia and Micronesia, while the second half is devoted to New Guinea, Melanesia and Australia. However, it proved impossible to be wholly consistent and to separate Melanesian Fiji from Samoa and Tonga.

In the **Polynesian** section the examples of decorated native bark cloth (tapa) are especially noteworthy, and a number of canoe models remind us that these people are daring seafarers. A series of ceremonial adzes from the Cook Islands in the farther quarter of the hall shows aboriginal carving at its highest level.

In the section on the right, the elaborately carved sacred masks, about 14 feet back of the Tahitian priest, illustrate the

A MANUS VILLAGE reconstructed with scientific accuracy in every detail: one of many miniature models in the American Museum showing native home life and activities.



æsthetic tendencies of **Melanesia**, which are also apparent in a carved pole set on top of a vertical case. Very different from these artistic manifestations are the carvings of the **New Zealanders** (Maori), characterized by the dominant spiral motive. The series of dried and tattooed Maori heads forms one of the most remarkable exhibits in the Museum. (See Guide Leaflet No. 71, *The Maoris and Their Arts.*)

Near the boundary between the two main sections are the **Australian** cases with numerous boomerangs and very crude stone tools, which should be compared with those in the archæological hall. The farther corner is devoted to a collection from the **Admiralty Islands**, including a model of a village of the Manus tribe, a lagoon-dwelling, fishing people who build their houses on piles



USIAI CARVED WOODEN BOWL FROM MELANESIA

BRIDE'S APRON OF SHELL MONEY: a Melanesian woman's dress used on festival occasions. Her costume is part of the payment which her kin make to her husband's family. The most important part of her dress comprises the two aprons woven of shell money

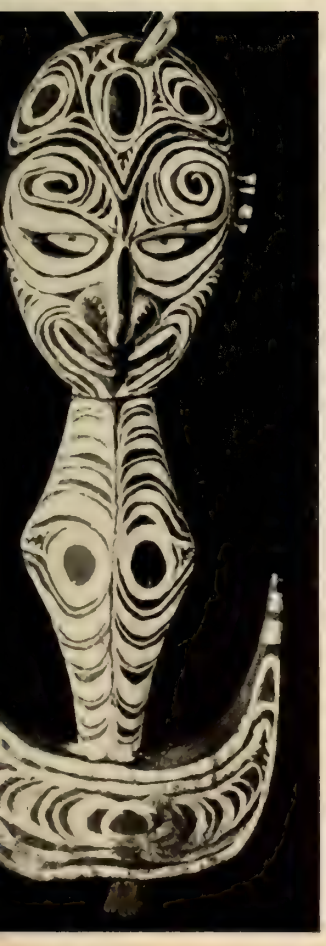




MELANESIAN MASK



MELANESIAN SACRED FLUTE



far from land. In the right corner of the hall are shields, clubs, carvings and household utensils from **New Guinea.**

The islands of the Pacific Ocean are of two kinds: first, those which are the remnants of a sunken land mass running southeast from Asia formerly connecting Australia and Tasmania with the mainland; and secondly, in the case of the numerous islands to the eastward, those which were formed by volcanic action and coral growth. The inhabitants belong physically to two very distinct races: the frizzly-haired, nearly black Papuans and the former inhabitants of Tasmania; and the wavy-haired, light-colored Polynesians of the islands stretching nearly across the Pacific. South of these islands are others inhabited by the Melanesians, who have straight or wavy hair and darker skins.

The cultural grouping is generally similar to that of the physical types. The Polynesians manufacture bark cloth and matting, have no pottery, drink kava, fight with clubs, and are skilled navigators. They are governed by chiefs who trace their ancestry back many generations. The Melanesians make some pottery, chew the betel nut, do grotesque carving, use bows and arrows for hunting and spears for fighting. They have secret societies and the men live in clubs. Between these two are the Micronesians, possessing some of the cultural traits of both their neighbors but differing considerably from each. Their islands being small, they depend for food chiefly on fish and pandanus and coconut palms. They are socially divided into castes: nobility, commoners, and slaves.

In addition to these cultural groups there are two specialized ones: the Polynesian Maori of New Zealand, and the Negroid inhabitants of Australia. The former have a very rich development of practical and aesthetic arts; the latter are

CARVED WOODEN HOOKS USED IN DECORATING MEN'S HOUSES IN NEW GUINEA



PHILIPPINE TREE HOUSE

almost without them. Besides, there are the inhabitants of New Guinea, generally Melanesian-like, but varying somewhat in race, language, and culture, and as yet not very well known.

Collections from Philippines and Malaysia

(Index Plan, p. 19, Floor IV, Hall 8)

This hall is reached by turning to the right in the South Sea Islands Hall.

The side aisles are devoted to the Philippine Islands. The farther section of the hall contains exhibits from other parts of Malaysia with an interesting series of marionettes from Java.

At the right of the entrance is a case containing life casts of faces, nose and hair from the different races represented in this hall, also charts of stature and head form, with distribution maps.

In the center is a model of a Filipino bamboo-walled and thatch-roofed house. At the far end a native tree house dominates the scene, and on the left may be seen the model of a woman weaving a garment on a native loom.

The visitor should note that, like the African Negroes, but unlike all other primitive stocks, the Malayan tribes represented in this hall used iron tools. The numerous iron weapons — spears, battle-axes, and krises (daggers with serpentine blades) — are especially remarkable.

On the left side of the hall will be found a number of synoptic exhibits of native krises, shields, fabrics, basketry and ceramics. Pottery is not highly developed in this area, but the textile arts flourish to a remarkable degree. The industrial life of the Bagobo of Mindanao is particularly well illustrated in the collections.

Much more primitive in their culture than the other Malaysians are the Negritos, a dark-skinned and frizzly-haired pygmy stock forming with similar groups in other parts of the world a distinct division of the Negro race. They are everywhere hunters, using the bow and arrow, and ignorant of agriculture. Their simple implements are shown in a table case in the farther section of the hall.

The islands lying close to the coast of Asia have been subjected to several migrations and to varying cultural contacts. Judging from the Andaman Islands and the Negrito remnants in the Philippine Islands, the original inhabitants were physically the most primitive of living men, related to the African Bushmen and the extinct Tasmanians. The present population is predominantly Malay in origin, members of the great Mongolian race. Their cultural arts include pottery, metal work, and textiles. The metal work is especially fine in the weapon-making of Java and among the Mohammedan inhabitants of the Philippines. Among the textiles are exhibited the batik work of Java, the tie dyeing of the Bagobo in the Philippines, and fine textiles of Luzon.

They possess fowls and pigs, cultivate rice, and use the Carabao, or water buffalo, as a domestic aid in agriculture and transportation. They possess the outrigger canoes generally in use throughout the Pacific. Their weapons are blow-guns, bows and arrows, spears, and knives. They are devoted to head-hunting, considering it necessary for religious peace and security.

The original culture of the first black race has disappeared. That existent at present is basic Malay, on which has been superimposed the influence of India and China, the former affecting thought and philosophy, and the latter furnishing, through commerce, cherished objects of art and utility. Next came Mohammedanism, which is the prevailing religion in some of the islands, and about three hundred years ago Christianity and European culture were brought by the Dutch and Spaniards.



AN EMPEROR'S BIRTHDAY GIFT. An assemblage of elaborate carvings fashioned from purest white jade and fitted together

Asiatic Collections

(Index Plan, p. 19, Floor IV, Hall 6, also Hall 4, and p. 18, Floor III, Hall 6)

The famous **Drummond Collection** of carved Chinese jade, amber, Japanese ivory, and sword-guards is in the Southwest Tower on the fourth floor, opening out of the South Sea Islands Hall. This magnificent collection gathered by the late Doctor I. Wyman Drummond and presented to the Museum in his memory, is installed as a unit, largely according to Doctor Drummond's original arrangement.

It is really a group of collections, each one of the greatest importance and beauty. The **jade collection** alone is a rich and well balanced series, representative of all periods and covering a cultural range of more than thirty centuries. The left half of the room is devoted to jade arranged by periods, while the right half is given over to **amber, ivory, lacquer** and **bronze sword-guards.** The oriental amber displayed is the finest of its kind in the world.

A unique composite piece of white jade, occupying the center of the room,

was a birthday gift to the Emperor Kien Lung from the officials of his court. This assemblage of jade carvings consists of thirteen pieces fashioned from purest white jade and fitted together. Surrounding the central piece are twelve segments fitted together, each of which is carved with a representation of one of the twelve terrestrial branches corresponding to the signs of the zodiac.

A very fine piece of white jade of the Kien Lung period of renaissance in glyptic art is in the form of a "Scepter of Good Luck" (Joo-i scepter). On the long handle of this piece are carved in high relief the figures of the Eight Immortals, the half-mythical, half-historical personages so often represented in Taoist art. Each of these carries some characteristic object, such as the flute of Han Hsiang-tzu, whose marvelous tone caused flowers to grow and blossom instantly.

Other fine examples of jade are also to be seen in the Morgan Gem Collection (Floor IV, Hall 4) and in the Asiatic Ethnology Hall on the third floor (Index Plan, p. 18, Floor III, Hall 6), where are installed collections from eastern and

JADE SCEPTER *(Right)*. From the Drummond Collection

JADE CUP *(Below)*. The dragons on this jade cup are of the form which developed in China in the Ming dynasty







K'WAN YIN, GODDESS OF THE FISH. A carved ivory Japanese figure of great beauty from the Drummond Collection. This ivory statuette is characteristically Japanese both in conception and rendering. It immortalizes in ivory the story of the princely fisherman who set up a shrine to this goddess after he had repeatedly found her image in his net instead of the fish he sought



WANG MU, THE CHINESE QUEEN OF THE FAIRIES. This is a carved ivory figure from the Drummond Collection. Though produced by a Japanese artist, it is founded upon a Chinese myth. It is said that the palace of Wang Mu is in the Juen-lun Mountains, where she guards the Tree of Immortal Peaches that grows beside the Lake of Gems, whose fruit ripens upon her birthday, every 3000 years. Here gather to the Feast of Peaches all the immortals to renew their immortality by eating the celestial fruit



CHINESE BRONZES. A set of three bronze ornaments inlaid with silver from the Sung Dynasty, 960-1279 A. D. To the right is a bronze libation cup, probably used in religious ceremonies, from the Shang Dynasty, 1766-1122 B. C.

northern Asia. Specimens illustrating the culture, industries, religion and manufacture of China are on the left. Others, showing the mode of life, the costumes, and the war implements of Siberia, are on the right.

The fur-work, costumes, and rugs of the people of eastern Siberia reveal remarkable skill in workmanship. Two models show respectively summer and winter scenes in Siberia. In the rear are collections from Japan, the Ainu and the Amur River tribes noted for decorated fabrics and picturesque costumes.

The collections on the left side of the hall deal mainly with the everyday life of the modern Chinese and have a special value, as they were made just before the sweeping changes of the last few years took place. These abolished many of the customs in which these objects were used. For example, the series of weapons and material showing the tests to which a soldier was submitted on entering the army have been rendered obsolete by the introduction of modern weapons and tactics. Bamboo, porcelain, basketry, inlaid work, cloisonné enamel, agricultural im-

THE EIGHT IMMORTALS. A group of figurines in Formosa coral depicting eight legendary beings who became immortal. From the Morgan Hall of Gems and Minerals on the fourth floor of the Museum





(Above) CHINESE BRONZE BOWL. This large bronze bowl has the original scroll design characteristic of the Chou dynasty. Attributed to the Han Period

(Below) A PAIR OF CHINESE BRONZE HORSES. They may have represented the horses of a chariot which has been lost. Ts In dynasty





SIX EXAMPLES OF CHINESE CLOISONNÉ ENAMEL FROM THE CHINESE COLLECTION OF THE MUSEUM



THREE BRONZE STATUETTES FROM THE TIBETAN COLLECTION. *(Above)* NARO KHE-CHO-MA. A feminine divinity, invoked to confer superhuman power



TSONG-KHA-PA. The great fifteenth century Reformer of Lamaism



YAK-HEADED RAKSAS
One of the animal-headed goddesses who appear in the Bardo, or After-Death State

plements, carvings in wood, ivory and stone, and examples of embroidery, are shown to advantage.

A special collection of great value is comprised in the ancient bronzes shown in the wall cases near the entrance. In the tower is the Whitney Collection from Tibet, illustrative of the costumes and religious rites of that little-known region.

An exhibit illustrates the production of cloisonné by the Chinese. A series of eight vases is displayed showing various stages of the process.

The foundation of all enamel objects is red copper of the shape and size desired. The decorations are first sketched on paper by special artists. These patterns are traced with a stylus on the copper. Vase No. 1 shows the simple copper foundation. No. 2 is a vase to which has been glued a network of thin copper wire following the tracings of the pattern. The whole is then powdered with a composite of silver filings, copper and borax (No. 3). The vase is now enclosed in an iron vise placed in an iron wire cage filled with burning charcoal which produces a perfect soldering (No. 4). Then an acid solution of apricots is brushed over it, and it is ready to receive the enamel. The enamel paste is troweled into the cell-like compartments ("cloisons") formed by the copper wire (No. 5).

After cooling, the vase is again exposed to the fire to properly harden the pigments. Nos. 6, 7, and 8 show the vases after successive firings. Very fine pieces of work may be fired eight times. Next the vases are polished with a steel file—then with sandstone and lime tree charcoal while the vase revolves on a lathe. Finally it is gilded.

The Koryak of Siberia. The Koryak live in northeastern Siberia, south of the Chukchee, between the Anadyr River and the central part of Kamchatka. Their number is about 7500. In language they are related to the Chukchee and Kamchadal, with whom they also share their arts and practices. Like the Chukchee, the Koryak are divided into a Reindeer and a Maritime Branch but differ from their neighbors in the almost exactly equal size of these divisions. The Reindeer

Koryak subsist mainly on the flesh of their herds. The Maritime group depend largely on fishing, while the hunting of sea mammals is also important but relatively less so than among the Maritime Chukchee. The Reindeer people live in movable tents. The stationary, partly underground house of the Maritime division is illustrated by a model in this hall. Both divisions of the Koryak wear clothing made of reindeer skins.

Before contact with other peoples the Koryak had no metal and made all their implements by chipping stone. At present, several settlements are renowned for their iron technique, which may antedate the coming of the Russians, since the Tungus and Yakut were both familiar with the blacksmith's art. The dressing of skins and the weaving of baskets by the coiled and twined methods are important industries. Remains brought to life by excavations of old dwellings show that the ancient Koryak knew how to manufacture pottery. In art the Koryak have attained a high degree of perfection as carvers in wood, antler, and ivory, as well as in the tasteful ornamentation of clothing and fur rugs.



(Right) KORYAK MAN IN ARMOR. Life size figure, clothed in original Koryak armor. From the Jesup North Pacific Collection

(Below) IVORY CARVING OF A BOY AND REINDEER FROM EASTERN SIBERIA







RED CAM-WOOD BOXES FROM MANG-BETULAND. These boxes have hollow sections of ivory engraved with hunting episodes like those shown above and below the picture. The tops represent the hairdress of a man and two women





AFRICAN TOM-TOM DRUMMER. Exhibited in the Akeley Memorial Hall of African Mammals. Sculptured by Malvina Hoffman

African Ethnology

(Index Plan, p. 18, Floor III, Hall 8)

The order in this hall is roughly geographical. Thus, as one proceeds through the hall he meets the tribes that would be found in passing from south to north in Africa, while the west coast is represented along the left-hand wall, the east coast along the right-hand wall, the central Congo tribes at the far end.

There are three aboriginal races in Africa: the Bushmen, the Hottentots, and the Negroes. In the north the Negroes have been greatly influenced by Hamitic and Semitic immigrants and have become mixed with them.

Nothing is more characteristic of the Negro culture, to which the rest of the hall is devoted, than the art of smelting iron and fashioning iron tools. The process used by the African blacksmith is illustrated in a group on the left, and the finished products, such as knives, axes and spears, are amply shown throughout the hall. The knowledge of the iron technique distinguishes the Negro culturally from the American Indian, the Oceanian, and the Australian.

All the Negroes cultivate the soil, the



WOODEN MASK FROM WESTERN AFRICA



CARVED IVORY ARTICLES FROM THE CONGO
Ivory carvings are among the most cherished possessions of African chiefs as the emblems of rank and power

women doing the actual tilling, while the men are hunters and, among pastoral tribes, herders. Clothing is either of skin, bark cloth, or loom-woven plant fiber. The manufacture of a skin cloak is illustrated by one of the figures in the group to the left of the entrance. Bark cloths from Uganda are shown in the farther right-hand section of the hall, while looms and the completed garments are shown in the large central rectangle devoted to Congo ethnology. The most beautiful of the last-mentioned products are the "pile cloths" of the Bakuba, woven by the men and supplied with decorative patterns by the women. Very fine wooden goblets and other carvings, especially a series of ivories from the Congo, bear witness to the high artistic sense of the African natives, who also ex-



IVORY HANDLED IRON WEAPONS OF THE MANGBETU. The great sickle-shaped knives were worn over the shoulder by the king and other prominent men when they were sitting in council, partly as proof of the wearer's readiness to strike. At other times the knives were pushed under the belt

cel other primitive races in their love for music, which is shown by the variety of their musical instruments.

A unique art is illustrated in the Benin case in the farther section of the hall, where the visitor will see bronze and brass castings made by a process similar to that used in Europe in the Renaissance period.

The religious beliefs of the natives are illustrated by numerous fetishes and charms, believed to give security in battle or to avert evils. Ceremonial masks are shown, which were worn by the native medicine-men.

HALL OF BIOLOGICAL PRINCIPLES AND APPLIED BIOLOGY

(Index Plan, p. 18, Floor III, Hall 12a)

Foods Needs and Food Economics: The north central part of this hall is devoted to the Food Exhibit, which shows in graphic form the needs of the human body. One case shows the chemical composition of the human body as represented by a man weighing 154 pounds. Special emphasis is laid on the need for mineral salts and for the indispensable elements called vitamins. Models illustrate the commoner foods which supply the daily needs of energy and vitamins.

The composition of certain familiar foods as regards protein, carbohydrates, fat, mineral salts, water and refuse is graphically represented. A special series of models shows the size of 100 calorie portions of the more important foodstuffs, and another exhibit stresses the necessity of eating the right quality of foods as well as the proper quantity. A combination of charts and a model represents sources of the world's food supply.

The remainder of this hall is devoted to exhibits dealing with Water Supply, Sewage Disposal, Insects, Rats and Parasites, and their Relation to Health.

Water Supply: The north end of the hall has models, maps, and charts which illustrate various phases of the problem of water supply. Relief maps of the region about Clinton, Massachusetts, before and after the construction of the Wachusett Reservoir for the water supply of Boston, show how surface water supplies are collected by impounding streams.

Several cases contain models illustrating the purification of water by storage, filtration, and disinfection.

A wall case located in the alcove of the north stairs has glass models of the principal microorganisms, Algae and Protozoa, which grow in reservoirs and impart tastes and odors to waters.

Sewage Disposal: A model depicts the dangers from improper disposal of the liquid wastes of the city and how they may be avoided, showing where polluted harbor waters and shellfish beds constitute a menace to health.

Modern methods for treatment of sewage on scientific lines are illustrated by a series of models of screens, sedimentation tanks, and filter beds of various types.

Insects, Rats and Parasites, and Disease. Charts, models, and maps form this exhibit. In the north central hall are two illuminated cases; one contains photomicrographs of disease-producing parasites, the other glass models of principal types of bacteria associated with disease.

Typhus and Other Diseases: In the alcove of the south stairs an exhibit is devoted to insect carriers of disease germs in tropical and semi-tropical countries. Specimens of *Glossina* are shown, which transmit sleeping sickness and the nagana disease in Africa; as well as the ticks, which spread Texas fever of cattle; relapsing fever; African tick fever; and Rocky Mountain spotted fever of man.

A series of small-scale models in the south end of the hall demonstrate methods and results of tropical sanitation for yellow fever prevention. A hospital at Panama is shown as it was during the former regime, with mosquito-breeding pools all about, contrasted with a modern hospital with no stagnant water and with wards screened and ventilated.

Flies and Disease: Models, specimens and charts deal with the life history of the fly, and other exhibits show how fly-breeding may be prevented.

Bubonic Plague: The relation of the flea and rat to the terrible bubonic plague is illustrated in considerable detail. In several cases are specimens of the principal animals which harbor the plague-germ and serve as reservoirs from which it is carried by the flea to man, such as the rat and California ground squirrel, and preventive measures are demonstrated.

Military Hygiene: The problem of military hygiene, so successfully solved during World War I, is graphicaly shown. Diagrams illustrate the relative deadliness of disease germs and bullets in earlier wars, reinforced by a representation of the relative importance of injuries received in action and effects of typhoid fever during the Spanish War.

AMERICAN MUSEUM OF NATURAL HISTORY

Founded in 1869

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THE MURALS

IN THE

THEODORE ROOSEVELT MEMORIAL HALL



AMERICAN MUSEUM OF NATURAL HISTORY

THE MURALS
IN THE
THEODORE ROOSEVELT
MEMORIAL HALL

Written by the Artist

WILLIAM ANDREW MACKAY

and

A. A. CANFIELD

of the New York State Department of Public Works

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MAN AND NATURE PUBLICATION 119

AMERICAN MUSEUM OF NATURAL HISTORY

The Murals in the Theodore R



ROOSEVELT'S EXPLORATIONS IN

The murals in the Roosevelt Memorial Hall were painted by William Andrew Mackay and are symbolical representations of notable incidents in the career of Theodore Roosevelt. The subjects are: "Roosevelt's Exploration in Africa (opposite the entrance door of the Memorial), "The Building of the Panama Canal" (to the right as one enters the Memorial), and "The Signing of the Treaty of Portsmouth" (to the left of the entrance).

Roosevelt Memorial Hall



AFRICA, 1910

⬆ [[*Over the Doorway*]] Against a background of a map of northern Africa is depicted the dispersal of the sons of Noah—Shem, Ham, and Japheth—after the voyage of the Ark. Ham, having shown disrespect to Noah, was cursed by his father and destined with his son and all his descendants to perpetual slavery. In the center appear Ham and his wife and his brothers Shem and Japheth at the parting of their ways. Beyond the lefthand edge of this illustration, the mural displays snow-capped Mount Kenya, with a fringe of bamboo forest on its slopes.





← [*Left center*] Theodore Roosevelt stands above a Nubian lion and lioness, flanked by his gun bearers. In this group are several birds which were added to the collections of the American Museum and the National Museum in Washington. The trophies are being studied by a Girl and Boy Scout. Theodore Roosevelt was one of the organizers of the Boy Scouts. Science is represented by a man in academic gown.

↓ [*Bottom left*] The shield combines symbolically Roosevelt's port of entry into Africa, Mombasa, indicated by the device of a red lion on a white disc, as it appears on the flag of British East Africa, and his point of departure, Alexandria, symbolized by Egyptian figures. Surrounding the shield are natives on *safari* carrying weapons and impedimenta of an expedition.



↑ [*Right*] In a tangle of gnarled trees, hemmed in by rocks, an African elephant is captured by a group of native hunters with shields and spears. At the bottom is the seal of the Smithsonian Institution of Washington, in the interests of which much of Roosevelt's African exploration was undertaken. Supporting the seal is a typical African native chief of the Kikuyu tribe, clad in a lion skin and blue headdress. At the left of this chief is Kermit Roosevelt.

⬅ [*North Return Panel*] The zebras, blended into an early morning African landscape, show the principle of concealing coloration in nature. At the base of this return panel appear several natives of the Masai tribe, who have returned from the hunt. The woman wears a gay skirt and brass-ring necklace, and the hunters are dressed in leopard and gazelle skins, one with a monkey-skin headdress.

➡ [*South Return Panel*] At the top, giraffes and ostriches blend into the landscape where they are usually found. Below upon a bent tree trunk crouches a leopard. At the base kneels a warrior with a taut bow and wearing two white ostrich plumes, evidence of his having slain two lions in single combat. Above him are the huge signal or war drums used by the natives. The entire panel is overlaid with beautiful red hibiscus and other rich African foliage.





BUILDING THE PANAMA CANAL

[*Over the Doorway*] A seated Buddha (not illustrated here) symbolizes what Columbus hoped and expected to find when he sailed west across the Atlantic Ocean—India. Seated on the right is Queen Isabella, and above her Christopher Columbus. On the left are an East Indian prince and a native.

[*Left center*] The three shields display (from left to right) a Mayan emblem on a blue field, a Toltec emblem (a carved stone called the cross of Tlaloc, found in Toltec ruins) on a red field, and the emblem of the Aztec nation at the time of the Spanish Conquest—an eagle holding a snake in his beak. The last-mentioned, somewhat modified, is the coat of arms of the Republic of Mexico at the present time. Between these shields, ships in battle recall the strife of early settlers with pirates.

Below these shields is emblazoned the mariner's compass, and at the right is a Mayan holding a ceremonial staff on which is perched the emblematic bird, the Quetzal. Beneath this figure are two pirates, one scanning the horizon with a telescope, the other having a hook in place of an arm lost in combat. Next are five women in ancient Spanish costume who display various products of the South American continent for which the Panama Canal provides export facilities.



The group dominated by Father Time signifies the transfer of the tugboat *Gatun*, the first craft to pass the Canal from one ocean to the other.

At the base of this panel the figures grouped about the shield of Panama represent the early founders in the development of this region. At the extreme left and right are men of the early races, the Mayan and Aztec. The figures next to the shield are a Spanish conquistador and an early pirate. The headdress of the Mayan priest is a crownlike structure adorned with feathers. The Aztec warriors carry weapons: left, a spear with flaming feather head and a huge chipped spear point; right, a sling and a bag of stones with a typical Aztec spiral design.



↑ [*Right center*] The three shields on this side of the center panel are the armorial design of Balboa, the discoverer of the Pacific Ocean, that of his Spanish sovereign, and the insigne of Republican France at the time when the Count de Lesseps initiated the enterprise of cutting a canal across the Isthmus. Below the shields are Balboa with the standard of Spain, and a pirate with the model of a pirate ship, a bag of gold, and a native monkey. At the right a Mayan of high rank holds a ceremonial staff. Beneath these appears Sir Henry Morgan, richly dressed in red, who raided the Spanish Main and eventually became Governor of Jamaica. Here also is a wrecked and rusted French excavating machine, covered with vines, remnants of which still exist beside the Canal bank. Near by is a French army officer holding plans

of the projected canal, Count de Lesseps in white, and France typified by the figure of a woman.

⬇ [*Immediately below*] President Theodore Roosevelt is seen discussing plans with Chief Engineer John F. Stevens. At the left an officer holds the flag of the Engineer Corps, United States Army. An officer of the Medical Corps, United States Army, in white uniform, holds a test tube, emblem of research into the causes of pestilence. A negro sprays the ground against the mosquito pest, responsible for the yellow fever which had defeated the French in their heroic efforts to build the Canal. Laborers hold a steam drill and a crowbar. Below is a model of the Gatun Locks.



⬇ [*At the bottom*] Color sergeants display the flag of the militia of the District of Columbia and the Presidential ensign with attendant elements of the Great Seal of the United States. The figures of Freedom at the left and Liberty at the right support a shield with the inscription: "Work on Panama Canal started May 4, 1904, by President Theodore Roosevelt. The land divided the world united. Completed 1914."





← [*Left, or West, Return Panel*] This shows the last act in the great excavation, the meeting of the two enormous excavating machines, facing each other in the final task of scooping up the remaining earth and rock of the cut. Over the map of the Canal Zone, the steam from the power shovels forms the outline of the divided continents. Below the excavators is what the artist has aptly termed "a typical American construction engineer" in a characteristic pose. This is a portrait of the New York State Superintendent of Public Works, Colonel Frederick Stuart Greene, under whose direction the Roosevelt Memorial building was constructed.

At the bottom of this panel is a typical Latin-American Canal laborer holding the coat of arms of the Canal Zone, surrounded by the armorial designs of France, Spain, Scotland, and Portugal. At the left are two natives using a loading iron, making preparations for a blast, and at the right are other typical figures engaged in the building of the Canal.

➡ [*Right, or East, Return Panel*] At the top is the Goddess of the River, crowned with orchids, pouring the dew from an ancient water vessel, which she has gathered from the rainbow. Down it falls to become the Unknown River, discovered and explored by Theodore Roosevelt, and named for him Rio Teodoro. The discoverer is viewing the river at its source, his native attendants with their propelling poles pushing aside the branches, disclosing the stream. The President's son, Kermit Roosevelt, is shown recording the saga.

At the bottom are members of the Parecis tribe of Indians. A warrior holds in his right hand a richly decorative shield of the map of South America with the arms of Portugal and of Brazil; in his left is an ancient musical instrument. The warriors are equipped with long bows and arrows, and one of the native women carries a basket suspended by a band from her head.



THE TREATY OF PORTSMOUTH SEPTEMBER 5, 1905

➡ The immediate theme of this section is, of course, the termination of the Russo-Japanese War through the mediation of President Roosevelt, but there is a deeper underlying idea brought out by the identity of treatment on either side of the center panel and a balance in the design, the whole brought to a focal point in the dominant figure at the top of the mural over the doorway. This is Jenghiz Khan, flanked by two of his sons, Juji and Jagatai. Jenghiz Khan, the greatest of Mongolian conquerors, typifies a common enemy engaged (to the left) in battle with early Russians, and (to the right) with medieval Japanese.



⬅ [*Left center*] Russians killed in battle lie in a wheat field, mourned by relatives and attended by a Russian priest with a deacon and a Russian nurse. Near the doorway are the figures of Death, Famine, and Plague.

At the base of this panel is the group gathered for the signing of the peace treaty. From left to right these figures are: Theodore Roosevelt, M. Takahira, C. Nabokoff, Count S. de Witte, J. Korostovetz, and Baron Komura. Count de Witte and Baron Komura are holding the olive branches of peace. The figure of Columbia with a sheathed sword draped with a band of mourning is behind Roosevelt.


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120
THE KHAN
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ISLAND OF
HONDO
SANGAM STR
PEKING
KALGAN
SO-PING
CHINA
JAPAN
SEA
SADO
IS
OKI
IS
NAGOYA





➡ [[*Right center*]] Here appears the Japanese Goddess of Mercy, Kwannon, her head encircled by a halo. The group of mourners is the counterpart of the Russian group opposite except for differences in racial types and costumes. A Shinto priest gazes upon the dead Japanese soldier, and the repeated figures of Death, Famine, and Plague emphasize that both nations face the same loss and ruin which follow war.

At the base of this panel, two typical American girls represent Justice and Mercy intervening between a Japanese and a Russian soldier. At the left of the base in full ceremonial vestments is the Emperor of Japan. Behind him is a banner bearing his "Mon" or armorial device in gold on blue. The rising sun banner of Japan flies above the figure of a Japanese infantryman, while the blue cross of St. Andrew on a white field stands above the Russian fighter. At the extreme right in coronation robes and wearing the imperial crown is the Tsar, above his head the two-headed eagle on gold ground, the emblem of Imperialist Russia. The Mikado and Tsar are offering their swords in token of peace between their nations, and this is repeated in the open book of history which appears in the center.



← [*Right, or West, Return Panel*] Japanese legendary history. Superimposed upon the map of Japan are depicted Izanagi and Izanami, deities of Japanese tradition, standing upon the "Floating Bridge of Heaven." They thrust a spear into the ocean, and the drops of water falling from it formed the island of Onegoro or "spontaneously-congealed-island." Dwelling in the island they saw a wagtail and its mate alighting on a stone. They conceived the idea of marriage, and are held to be progenitors of "The Great Island Country." Wishing descendants to rule over the country, they became the parents of the Sun Goddess, Amaterasu.

Amaterasu appears below, where she has retreated into "The Rock Cave of Heaven" to avoid her unruly brother Susanoo. She has refused to see him before his banishment to the Land of Yomi (Hades), and the Gods



and Goddesses are disturbed at the prospect of darkness. Before the cave they have planted a Sakaki tree and upon it hung a mirror, a rosary of 500 jewels, and offerings of blue and white cloth. They finally induced the Sun Goddess to look upon a goddess more beautiful than herself—her own reflection in the mirror—and the goddess emerges from the cavern. Her consort, Tsuki, the Moon God, is shown above her.

Below is Susanoo in the act of slaying the eight-headed serpent after it had drunk a quantity of rice wine. In the background is the sacred mountain Fuji, and in the foreground, sword in hand, stands the first historic Japanese Emperor, Jimmu, descendant of Amaterasu, the Sun Goddess.

At the bottom of this panel is the armorial design of the Scottish family of Bulloch, the maternal ancestors of Theodore Roosevelt.



←[[*Left, or East, Return Panel*]] Russian legendary history. At the top is a primitive North Russian, kneeling, stringing his bow. Near him, holding spear and shield, stands the Norseman, Rurik, first historic ruler of a unified federation of Slavic tribes. The map background indicates the region of Novgorod, where Rurik first established his power.

Next below is Oleg, companion and brother-in-law of Rurik, who became Regent on Rurik's death in 879, during the minority of Igor, Rurik's son. Here Oleg is shown approaching a horse's skull. It had been foretold that he would die by reason of his horse. On its death Oleg was reassured, but going to look for the last time on its remains, a snake issued from the skull and bit him, thereby killing him. Next below appears Igor, son of Rurik, fighting with a Greek warrior, typifying his war with the Greeks in 941–944 A.D. Igor's Queen Olga held the Regency while her son Sviatoslav was a child. She is shown



enemies' thatched roofs. The pigeons were the only tribute she had demanded, and returning them with the fire, Olga avenged the deaths of her husband and her son. The figure to the right is a chief of the Petchenegs, enemies who slew Sviatoslav, who holds a drinking cup made of Sviatoslav's skull bearing the inscription, "He who grasped at the possessions of others lost all that was his own."

In the background is a Russian church. Olga first introduced Christianity into Russia. Her grandson, Vladimir, besieged a Greek city and finally captured it after an arrow bearing a message revealing the location of the city water supply had been treacherously shot into his camp. He married the Greek princess of the city, and brought the Orthodox Greek religion to Russia as its established religion.

At the bottom of this panel are shown members of the Roosevelt family grouped around their armorial shield.

Notes about the Competition and the Artist

An open competition was held in New York City in March, 1933, for the selection of designs by an American artist for the mural paintings for the New York State Roosevelt Memorial. Twenty-five artists anonymously entered sketches. The jury consisted of Colonel Frederick Stuart Greene, the Superintendent of Public Works; William E. Haugaard, the State Commissioner of Architecture; John Russell Pope, architect of the Roosevelt Memorial; the Board of Trustees of the New York State Roosevelt Memorial, namely, Governor Herbert H. Lehman, *ex officio*; Henry Fairfield Osborn, Chairman; Peter D. Kiernan, Vice-Chairman; Mrs. Richard Derby; Charles W. Flint; Mrs. William H. Good; Chauncey J. Hamlin; Felix M. Warburg; and Abram Poole, an artist selected by the contesting artists. By unanimous vote they awarded the work to William Andrew Mackay. Colonel Greene, approving the choice and signing the sketches, contracted with Mr. Mackay for the execution of the work, which was completed and installed on the walls of the Memorial in April, 1935.

The area covered is about 5,230 square feet. The canvasses are 34 feet in height and, including the wing panels, 62 feet in length.

The late Mr. Mackay, a descendant of an old American family, was educated at City College, New York City, and studied at the Julien Academy in Paris. In his early career he assisted the great painter, Robert Reid, later being associated with Frank Millet and Elmer E. Garnsey, upon whom he looked as his master. During World War I Mr. Mackay was Chief Camoufleur of the Second District, including Newport, Cape May, and New York Harbor.

Many very fine examples of decorative work have been executed by Mr. Mackay in the Library of Congress, in the Belmont Memorial Chapel, and the famous Chinese Tea House at Newport, Rhode Island. His mural painting "The Legend of the Sargasso Sea" at Castle Gould won honorable mention at the Architectural League.

A Message from THEODORE ROOSEVELT

NATURE

There is a delight in the hardy life of the open
(African Game Trails)

There are no words that can tell the hidden spirit of the wilderness, that can reveal its mystery, its melancholy and its charm
(African Game Trails)

The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased; and not impaired in value
(The New Nationalism)

Conservation means development as much as it does protection
(The New Nationalism)

MANHOOD

A man's usefulness depends upon his living up to his ideals insofar as he can
(A Letter to Dr. Sturgis Bigelow, March 29, 1898)

It is hard to fail, but it is worse never to have tried to succeed
(The Strenous Life)

All daring and courage, all iron endurance of misfortune—make for a finer, nobler type of manhood
(The Great Adventure)

Only those are fit to live who do not fear to die; and none are fit to die who have shrunk from the joy of life and the duty of life
(Address before Naval War College, June, 1897)

YOUTH

I want to see you game, boys, I want to see you brave and manly, and I also want to see you gentle and tender
(Address at Friends School, May 24, 1907)

Be practical as well as generous in your ideals. Keep your eyes on the stars and keep your feet on the ground
(Speech at Prize Day Exercises at Groton School, May 24, 1904)



Character, in the long run, is the decisive factor in the life of an individual and of nations alike
(American Ideals)

THE STATE

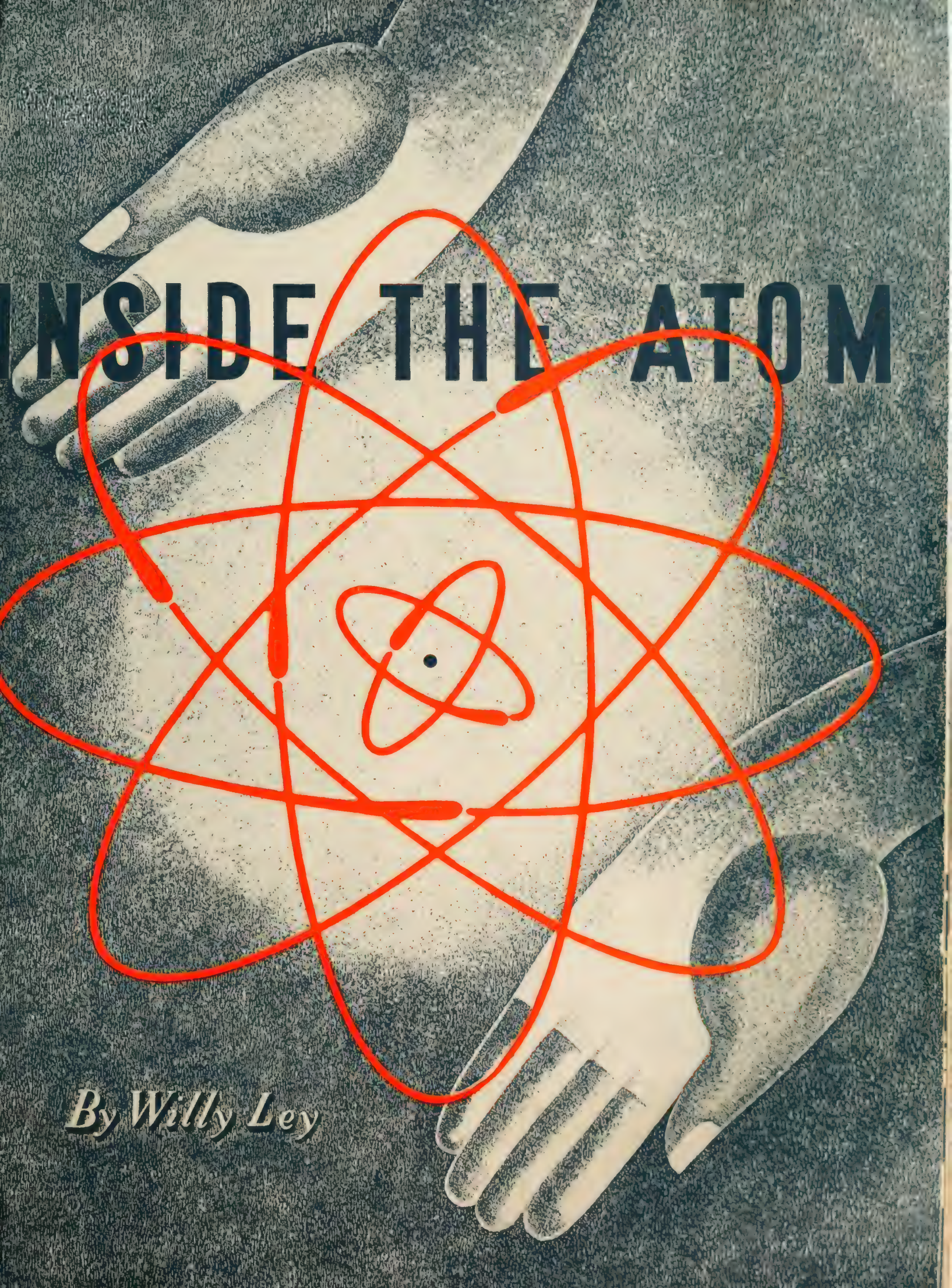
Ours is a government of liberty by, through, and under the law
(Speech at Spokane, Wash., May 26, 1903)

A great democracy must be progressive or it will soon cease to be great or a democracy
(The New Nationalism)

Aggressive fighting for the right is the noblest sport the world affords
(Miscellaneous Writings)

In popular government results worth having can only be achieved by men who combine worthy ideals with practical good sense
(Address at Harvard Union, Feb. 23rd, 1907)

If I must choose between righteousness and peace I choose righteousness
(America and the World War)


INSIDE THE ATOM
By Willy Ley

INSIDE THE ATOM

By

WILLY LEY

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Man and the Atom

As the explosions of the first atomic bombs recede into time and the rubble of destruction settles on the scarred landscape, the issues raised by man's use of atomic energy become clearer. The exultation, the joy, and the relief in our minds that we had at last the power and ability to destroy our enemy completely, should he refuse to cease the struggle, are replaced by a profound concern about a future exposed to the uses of atomic energy.

Now that we have it, what are we going to do with it? This question, of course, involves more than the temporary measure of keeping its secrets safe within our own councils, for it is clear that we cannot hope to remain the sole guardian of the scientific knowledge that has made the atomic bomb possible. The basic principles are common property, and it is only a matter of time before other nations will have learned the final steps that we have already mastered. Under such circumstances, it is useless to urge that the knowledge of the means of harnessing atomic energy be obliterated in order to protect ourselves or our successors from their own folly, even if we had the moral right to deny the vast possibilities for good that are inherent in such knowledge.

The consequences, moreover, of attempting to destroy the knowledge of atomic energy, and therefore to declare it by mutual agreement to be a *terra prohibita,* would eventually result in blocking the advance of physics along other and more innocent fronts. Science cannot progress, leaving behind it unknown areas set aside and marked dangerous. Mankind is too comfortably installed on a *de luxe* express named "Science." There are no stops.

It is perhaps salutary, as we contemplate the future, to view this discovery in the perspective of human development. In a very real sense the history of man is the story of an expanding use of energy outside the human organism. The discovery of atomic energy represents only the latest achievement in acquiring sources of energy and thereby devising means of harvesting natural resources for our material and even spiritual welfare. Beginning with the use of fire, man has gradually and with quickening tempo tapped one source of energy after another. With each of these achievements, he has laid open vast areas for good as well as acquired the means of destruction. Fire itself, used by man for perhaps 500,000 years, still requires vigilance and control. Is it conceivable that men should abandon these present powers because of their latent evil? Should we give up our automobiles because they are used recklessly and unwisely by some, our radios because they are possible means of spreading pernicious propaganda, our airplanes because they may carry bombs? Who can predict what alleviations of human misery atomic energy may bring? And although we recognize the dangers, are these benefits to be rejected for fear of its misuse?

There are those who advocate that mankind should first learn moral restraint and social responsibility before being entrusted with undue power. But who shall judge when man will have reached that point in his development, and how may he achieve such virtues in the absence of the responsibilities that force him to acquire them? Moreover, it may be said that man has never been completely ready socially or morally for each new source of power that he has acquired. The apelike beings who first discovered the beneficent uses of fire were no better organized to control it than we who today have within our grasp the vastly greater quotient of energy locked in the atom.

Since, however, atomic energy is here and is likely to stay, it is the solemn obligation of scientists, particularly those concerned with human affairs, and of all men of vision, to work for a political and social organization of mankind that will, by making war impossible, permit us to employ our powers without disaster.

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Inside the ATOM

By WILLY LEY



The word the Greeks had for it meant "indivisible." Twenty centuries were necessary to show that the atom is divisible and that its energy is great enough to revolutionize peace as well as war

NOTHING in the whole history of human thought has ever received as wrong a name as the atom. Both the idea of its existence and its name originated in the world of Classic Greek philosophy. The word that is the root for our word "atom" is the Greek *atomos,* which means "indivisible." Even the man on the street now knows that nothing divides more spectacularly than the atom.

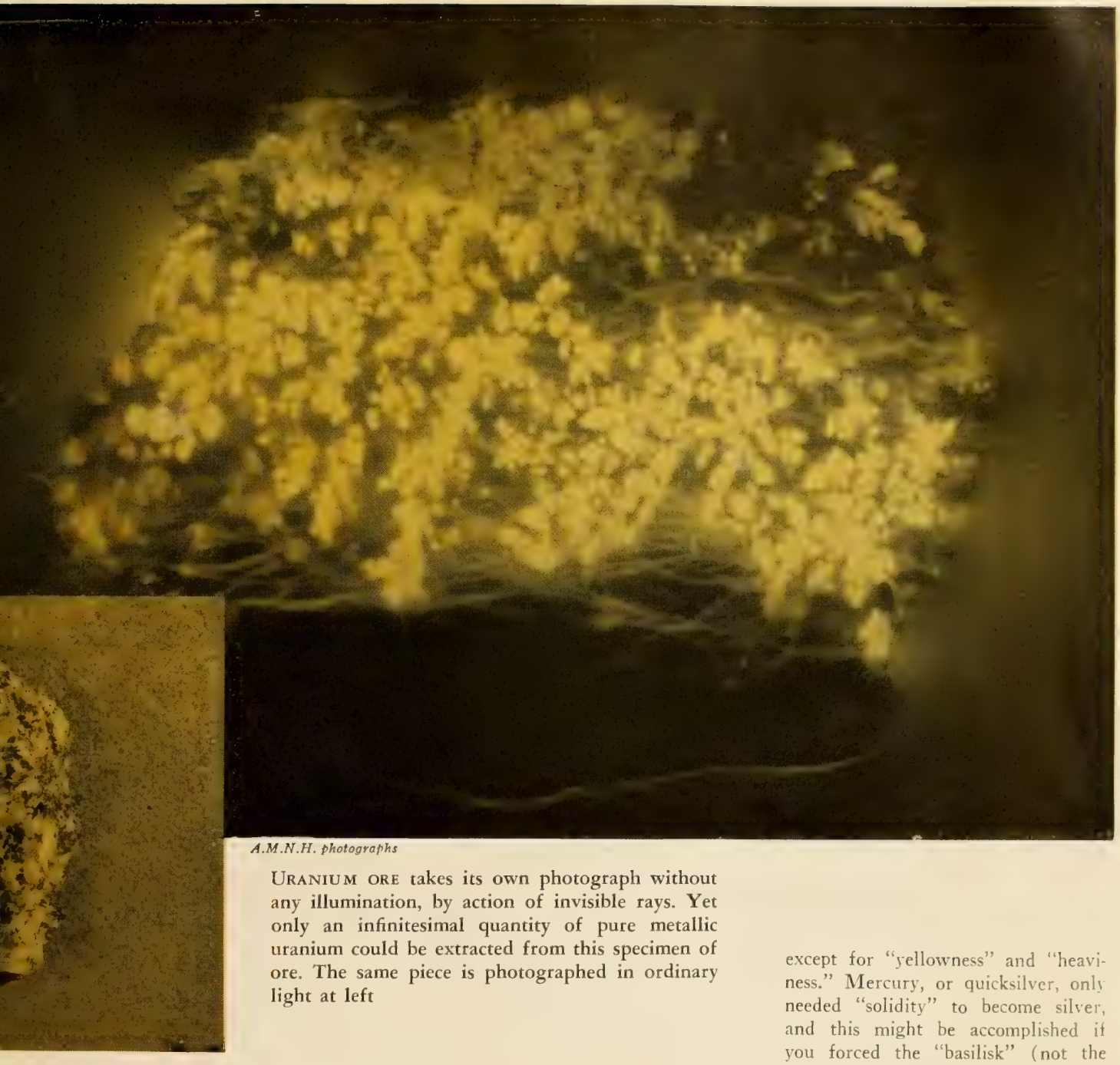
The weapon that helped to blast Japan out of the war with two enormous blows depends upon the explosion of these "indivisible" particles, which contain the most incredible amounts of energy.

Like all ideas, the concept of the atom as the ultimate particle of matter grew from small and simple beginnings. The best way to understand what has been done during the last four years under extreme secrecy in American laboratories is to trace the growth of that idea. The "father" of the atom was a Greek natural philosopher, Democritus the Abderite, who was born in Abdera in Thrace in about 460 B.C. That he followed, in part, the teachings of one Leucippus who lived about half a century earlier should not detract from his glory.

Students at the time of Democritus were groping for an explanation of the basic differences between various substances. Democritus argued that all substances must consist of a number of fundamental pieces. Thus the idea arose that water was composed of particles that were very round and smooth (as we would say, like small polished steel balls) and therefore easy to part, while the atoms of iron were rough and therefore difficult to part. Atoms of acid were supposed to be covered with little hooks which made them sharp and grasping.

These particles differed in shape and arrangement and possibly in magnitude and weight. Also they were capable of movement. But their chief peculiarity was that they were indivisible. Each was so small that it could not be reduced further; hence the word "atom."

All this sounded reasonable enough, and the idea of indivisible atoms retained its validity with but little change until half a century ago. People assumed that there had to be an



A.M.N.H. photographs

URANIUM ORE takes its own photograph without any illumination, by action of invisible rays. Yet only an infinitesimal quantity of pure metallic uranium could be extracted from this specimen of ore. The same piece is photographed in ordinary light at left

irreducible particle, and atoms filled the bill.

It should be remembered that Democritus' atoms were purely philosophical and not supported by any experimental evidence. They were as much the product of belief as of reasoning; therefore, nobody was obliged to accept their existence. Aristotle had no use for them, and while his biting criticism failed to kill the idea of atoms once and for all, the atomists did not rise to a dominant position in natural philosophy and remained but *one* philosophical school among many.

Throughout the Middle Ages the idea remained static. The alchemists did not like "unchangeable" atoms, because their goal was the transmutation of metals, particularly the making of gold from baser elements. Some alchemists, to be sure, had idealistic goals such as the *aurum potabile,* or "drinkable gold," which was to cure all ills. But most of them were content to try for solid gold, stating euphemistically that they were looking for the Cure for the Great Illness of Poverty.

They had their own theories to go by. Chalk, for example, was thought to be the same as sulphur, except that chalk lacked "yellowness" and "combustibility." If you could impart "yellowness" and "combustibility" to chalk, you would have sulphur. Likewise, silver was the same as gold except for "yellowness" and "heaviness." Mercury, or quicksilver, only needed "solidity" to become silver, and this might be accomplished if you forced the "basilisk" (not the same as the "king of serpents" of medieval zoology, but a demonic concept) in the mercury, to part from it. If in addition, you could impart "yellowness," say from sulphur, you would have gold.

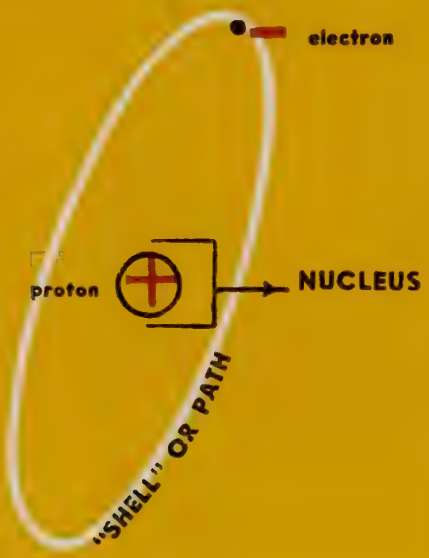
In the course of time, theories of alchemy disappeared to make room for other ideas which, although wrong in themselves, were much more effective because they led to more systematic experimentation.

Around the year 1800 the time was evidently ripe for the revival of the atoms of old. This was done by an English chemist, John Dalton, whose ideas had been directed into atomistic channels, curiously enough, through the avenue of weather observations. Seeing rain fall and disappear again,

WHAT IS AN ATOM?

1

A HYDROGEN ATOM has one proton (a positively charged particle) as a central mass, or nucleus. This is balanced by one electron (negatively charged) moving around it



2

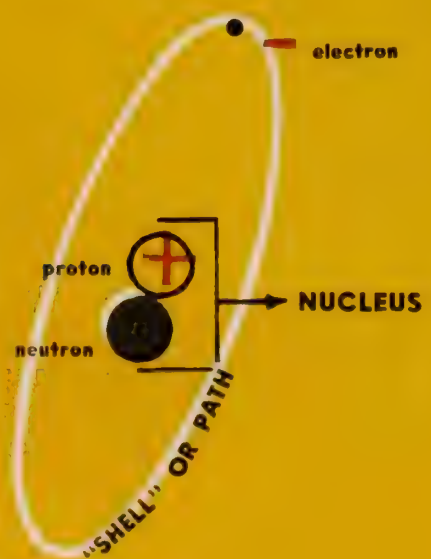
IT takes 1840 electrons to equal the weight of one proton



The whole atom is so small that it is far beyond the range of the electron microscope

3

BESIDES ELECTRONS and protons there are also neutrons, particles that are neutral in the electric sense but have weight. If there is a neutron in the hydrogen nucleus, we have "heavy hydrogen," which forms "heavy water"



Dalton could think of no other explanation than that both water and air consisted of tiny separate particles; otherwise the evaporating water could not enter the air. Observations in the chemical laboratory helped this idea along. Hydrogen and oxygen combined to form water always in a given and rigid weight ratio, no matter how it was done.

After enough facts of this kind had been amassed, Dalton was able in 1808 to write the following:

"These observations have led to the conclusion which seems universally adopted, that all bodies of sensible magnitude, whether liquid or solid, are constituted of a vast number of extremely small particles, or atoms of matter, bound together by a force of attraction, which is more or less powerful according to circumstances. . . . Chemical analysis and synthesis go no farther than to the separation of particles one from another, and to their reunion. No new creation or destruction of matter is within the reach of chemical agency. We might as well attempt to introduce a new planet into the solar system, or to annihilate one already in existence, as to create or destroy a particle of hydrogen. All the changes we can introduce consist in separating particles that are in a state of cohesion or combination, and joining those that were previously at a distance."

Dalton's words became the basis of chemical thought for a full century, and still hold true for chemistry proper. He said, in brief, that all chemical elements consist of minute particles that cannot be subivided further—in other words, atoms. These atoms could form an enormous number of combinations with one another. The smallest possible particle that represented such a combination then recevied a new name, molecule (meaning "small bundle") and the customary classroom explanation sounded like this: By mechanical means, as for example through evaporation, you can divide and subdivide a droplet of water until you arrive at a very small quantity, the water molecule, that can no longer be subdivided and still be water. If you take that molecule apart, you no longer have water but only the elements composing it—in this case, two atoms of hydrogen and one of oxygen.

It rapidly became clear that the atoms of the elements were not all of the same weight. The atom of hydrogen had to be lighter (and presumably

smaller) than that of carbon. The carbon atom, in turn, was lighter than the oxygen atom, and the oxygen atom lighter than that of silver. The weight of the atom did not, however, determine the weight of the substance. The atom of gold, for instance, is lighter than the atom of lead, though gold itself is heavier than an equal volume of lead. The atoms of gold happen to be more closely packed.

The relative atomic weight of hydrogen was arbitrarily called "1," and the carbon atom was found to be about 12, that of oxygen almost precisely 16, silver about 108, gold about 197, and lead about 207. These weights were only approximate, but the differences were small. And the English chemist Prout, as early as 1815, ventured the guess that these small differences might be merely mistakes and that all the elements were probably just combinations of various numbers of hydrogen atoms.

This sounded intriguing, especially since it recalled another guess of the alchemists, namely that there was a primary substance, a *prima materia,* of which all other substances were composed. But Prout's idea could not be proved, because the small "mistakes" were stubborn and persistent. Sometimes the figures underwent slight changes when improved methods were used, but they never became the even figures that Prout's guess demanded.

Latér in the century, however, a different type of progress was made along similar lines. Two chemists set out, independently and at about the same time, to arrange the known elements in a logical order according to their atomic weights. They finally succeeded in doing this by leaving a few holes in their tabulations, holes which they hoped and predicted would be filled later by the discovery of additional elements. That was in 1869, and the names of the two men were Lothar Meyer and Dmitri Ivanovich Mendelyeev. Both came to about the same conclusions, but Mendelyeev's name became attached to this Periodic System of the Elements, mainly because he had made several very good predictions about the then unknown elements. One after another, the holes in the table were rapidly filled in, but one of the newcomers was so unusual that it looked for a moment as though the whole Periodic System would have to be thrown out on its account.

That newcomer was radium. The

KINDS OF ATOMS

THE ELEMENTS, such as gold, silver, oxygen, etc., have long been considered the basic substances that cannot be separated into different substances, only combined with each other to form compounds

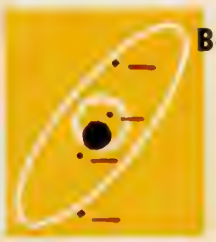
Each element is made up of its characteristic atoms, which differ in the number and distribution of their electrically charged particles



THE HELIUM ATOM is almost as simple as the hydrogen atom. But it has two positive protons in the nucleus and two electrons to balance them. Its greater weight, however, shows that the nucleus has also two neutrons



LITHIUM has three protons in the nucleus (here shown simply as a solid body). The three electrons that balance them cannot all get on the inner path, or "shell." One of them is farther out



BERYLLIUM has two electrons on the inner path or "shell" and two on the outer one To balance these four electrons, there must be four protons in the nucleus. The beryllium atom is therefore heavier than that of lithium and helium

BORON has five electrons on the two paths or "shells." These "shells" can accommodate a total of ten, and when they do, the atom is said to be "satisfied." The boron atom is not "satisfied" and therefore will readily combine with other elements





CARBON has a total of six electrons (negative particles) in the two shells. They are balanced, of course, by six protons (positive) in the nucleus







NITROGEN, oxygen, and fluorine have seven, eight, and nine electrons respectively. The same number of protons balance them in each case



NEON has all ten electrons that can be accommodated on the first two paths or "shells." It is therefore "satisfied" and is a chemically inert element

name itself, derived from the Latin *radius* ("ray"), described its main peculiarity. It was then found that other substances also gave off radiant energy. One of these was uranium, atomically the heaviest of all known elements and therefore number 92 in the table. It was named uranium in 1789, the year of its discovery, because the planet Uranus had become known some eight years earlier and Klaproth, the discoverer of uranium, meant to honor the astronomical discovery by transferring the name of the new planet to his new element.

A new science sprang into being at the beginning of the present century, the science of radioactive substances. John Dalton had not been able to explain evaporation without assuming that all matter consisted of tiny particles. Radioactivity now compelled its investigators to assume that the very heavy atoms at the upper end of the periodic table emitted still smaller particles. It seemed that these very large atoms,—those of radium, actinium, uranium, etc.,—had grown too large to hold together very well. They decayed and in decaying gave off radiation, which is energy in the form of particles smaller than an atom, subatomic particles.

Sir William Ramsay, one of the investigators of the new mystery, could not refrain from writing a poem, which he titled "The Death Knell of the Atom":

. . . So the atoms in turn, we now clearly discern
Fly to bits with the utmost facility;
They wend on their way, and, in splitting, display
An absolute lack of stability.

Electrical research tied in with these discoveries of the instability of the heavy atoms. Physicists had arrived at the conclusion that electricity was discontinuous, that it had to consist of particles of some kind. A flow of electricity was not like the steady beam from a searchlight, but rather like the stream of bullets from a machine gun. The smallest particles were called electrons, from the word the Greeks had for amber, the substance which when rubbed would pick up bits of paper.

These negatively charged particles (electrons) turned out to be one of the building stones of the atoms. It was a logical sequel that there must be particles having an opposite or positive electric charge, but although their manifestations had been discovered as early as 1886, they were not named until 1920. They were called protons, and it can be remembered that they are positive because both words begin with "p." It was found that these protons, while carrying a positive charge of the same amount as an electron, were much more massive. The best figure at pres-



ent says that one proton has the mass of 1840 electrons.

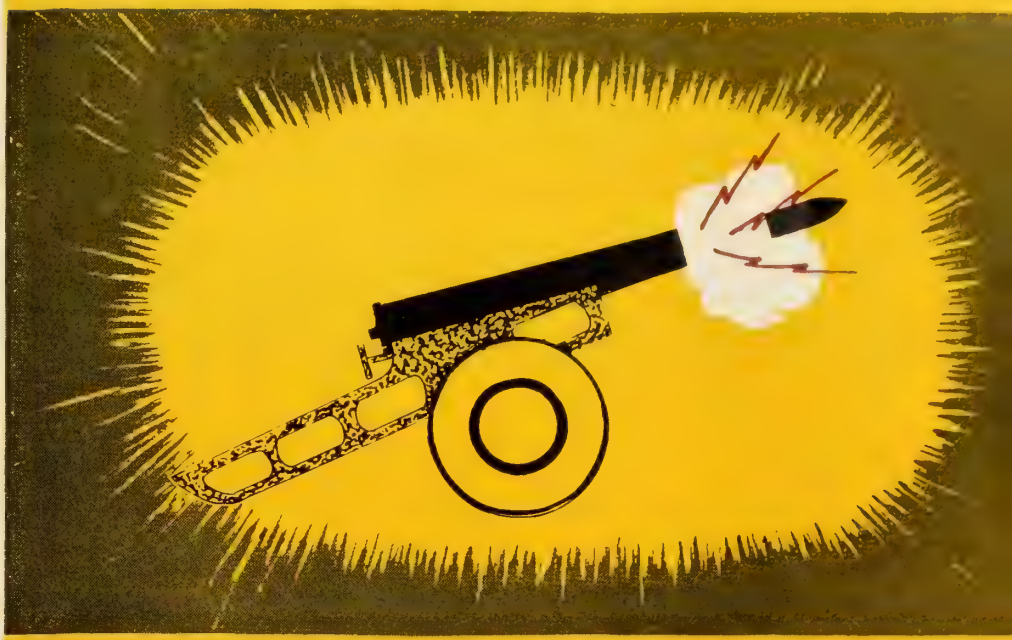
It was about that time that Niels Bohr evolved his famous theory of atomic structure. While there have been other attempts to describe the atom, Bohr's has best stood the test of time, and it is the only one that is easy to visualize. According to his theory, an atom can be compared to the solar system, in which the various planets move in curved paths around the sun. In the center is the main mass, the nucleus or heart of the atom, carrying one or more positive electric charges. Around the nucleus whirl planet electrons, as many as are required to counter-balance the positive charge of the nucleus. We might say that the atom is a positively charged mass surrounded by a veil of negative electricity.

Now the mass of one proton is just about the same as the mass of a hyrogen atom. Therefore it was reasoned that a hydrogen atom consisted of one proton in the nucleus, circled by a single tiny electron.

Hydrogen is element number 1 in the atomic table, with a weight of 1.008. Element number 2 is helium, with a weight of 4.003. But the nucleus of this atom, also called alpha particle, carries only two positive charges electrically balancing its two electrons. This would add up to only little over half the known atomic weight of the helium atom. Apparently there had to be a mass in the nucleus without any electric charge. It was at this point that a suggestion made by Lord Rutherford of Nelson in 1920 proved useful. Rutherford had suggested the existence of a subatomic particle called a neutron—in other words, a particle that was neutral in the electrical sense. It was said to have the same or about the same mass as a proton, but without any charge. The nucleus of helium, consequently, was understood to consist of two protons and two neutrons, with two electrons moving around it in a single orbit.

Element number 3, lithium, has an atomic weight of about 7; hence its nucleus contains three protons and four neutrons, with three relatively weightless electrons circling round it. Two of these electrons were the same in position and arrangement as those of helium, but the third electron moved in another orbit farther out. That second orbit, or "shell" as it is known technically, can take up to eight electrons; then it is full, or

THE BEHAVIOR of radio-active elements suggested how the atom might be smashed. A radio-active atom can be compared to a cannon. The bullet is the so-called alpha particle (or helium nucleus). The smoke is the beta "radiation." And the flash is the gamma radiation



IF a slow-moving neutron is shot at a Uranium-235 atom,



this happens:

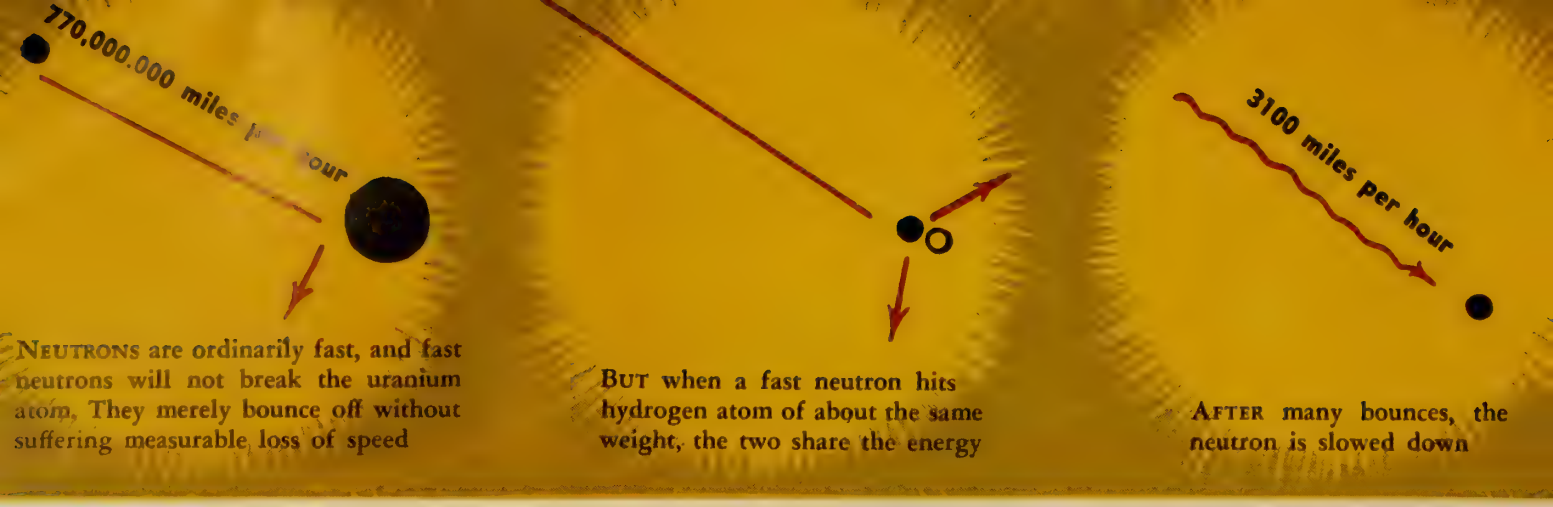


THE ATOM breaks apart and forms two atoms (usually barium and krypton), releasing enormous energy and sending out four neutrons

THE ENERGY released is 200 million electron volts

COMPARED with only 14 million

from normal radio-active elements



NEUTRONS are ordinarily fast, and fast neutrons will not break the uranium atom. They merely bounce off without suffering measurable loss of speed

BUT when a fast neutron hits hydrogen atom of about the same weight, the two share the energy

AFTER many bounces, the neutron is slowed down

"satisfied." This is the case with neon (element number 10), in which ten electrons balance a nucleus containing ten protons and ten neutrons, to give an atomic weight of about 20.

Element number 11, sodium, had one more electron still farther out, in a third shell. If the outer shell in any instance is full or satisfied, we have an element that shows no inclination to form any compounds, for instance helium, neon, and with more shells, argon, krypton, and xenon. But if the outer shell is not full, chemical activity results. Sodium atoms have one electron in the third shell, chlorine atoms have seven. These two elements combine very readily. But all these chemical combinations take place in the outer shells; they do not touch the nuclei. Hence atoms go into chemical compounds and out of them again without experiencing any change. If you want to change the atom itself, you have to attack the nucleus.

The attack on the nucleus, popularly called "atom smashing," became the big problem. Obviously, the only way in which one could attack the very small nucleus was to shoot at it with still smaller particles. The behavior of the radioactive elements themselves suggested what might be done. When a radioactive atom convulsed, it shot out an alpha particle (or helium nucleus) accompanied by two types of radiation, called beta and gamma rays. The beta "rays" were streams of electrons. The gamma rays were true radiation, comparable to the very hardest variety of X-rays.

To help us visualize this occurrence, there is a beautiful comparison. The emission of an alpha particle corresponds exactly to the firing of a gun. The heavy alpha particle is like the bullet. The beta "radiation" is the smoke, less substantial and lighter. And the burst of gamma radiation is the flash, impressive but non-material. The same gun, needless to say, was fired back at the atom in the effort to break it.

All the machinery that received newspaper publicity from time to time—the van de Graaff generator and finally the cyclotron—were only atomic cannon. They were machines designed to fire subatomic particles, especially alpha particles, protons and deuterons, into atoms. Physicists learned a great deal while inventing, constructing, and using this machinery. The dreams of the alchemists were realized to some extent: some elements were actually changed into others. Atoms were hit and chipped; but the military significance of these experiments was not too impressive. Most of the time, the damage was only comparable to a hole put through the funnel of an enemy steamer. Only very rarely was an atom really broken up. Especially obstinate in the face of the bombardment were the heavy atoms, which one could assume might ultimately be the most satisfactory targets.

Then, in 1939 and 1940, the great problem was solved, at least in one particular case, the case that led in a straight line to the atomic bomb. The Italian physicist Enrico Fermi, later of Columbia University in New York, working with uranium, made an observation that could not even be explained at first. For a short time Fermi thought that he had discovered a new element. Other researchers took up the trail, and in view of the political events then brewing, the situation became critical, for they were German scientists—Drs. Hahn, Strassmann, and Lise Meitner. Dr. Meitner left Germany and aided the scientists of the United Nations.

They found that what had happened was an absolute novelty. A uranium atom had not simply had pieces chipped off by a subatomic bullet: it had exploded like a torpedoed ship! The nucleus had broken into two pieces of approximately the same mass, sending out streams of energy on an unprecedented scale. Physical science even lacked a term for this performance and had to borrow the word "fission" (a cleaving, or breaking up into parts) from the biologists.

It was the first time that one of the really heavy atoms had yielded, and it had yielded not so much to brute force as to persuasion. Not a fast-moving alpha particle but a slow-moving neutron caused the fission of the uranium atom. But not every uranium atom responded.

It had already been learned that the established elements sometimes masqueraded in slightly different costumes. The so-called "heavy water" that was recently discovered is "heavy" because its hydrogen atom is one of these variant forms. Likewise, in addition to the usual helium 4, there is helium 3, with only one neutron instead of two; and there is lithium 6 as well as lithium 7. Chemically there is no difference, but the atoms have different weights. These variant forms of an element are called isotopes.

In the case of uranium, there were U-234, 235, 236, 237, and 238, the last being the most common type. U-236 and U-237 are not stable; U-234 is very rare; but U-235 is compartively abundant, one out of every 140 uranium atoms being of this type. And U-235, with 143 neutrons instead of 146, goes into fission as soon as a slow neutron wanders in.

The explosion or collapse (either term applies, depending upon the point of view) is restricted to that one atom. The atom gives off four additional neutrons in the process of breaking up, but these are fast neutrons and therefore do not touch the nuclei of other atoms. It seems that

a fast neutron, when it runs into a heavy atom of any kind, mostly just bounces off without apparent loss in speed.

The two problems that arose as soon as these facts were known were: (a) how can one extract U-235 in large quantities from the customary mixture of U-238 and U-235, and (b) how can one slow down those four neutrons that are released so that they will in turn cause other atoms to explode and produce what is called a chain reaction.

The problem of separating U-235 from regular uranium (U-238 plus U-235) was extremely tedious, as can be imagined from the size of the factories that had to be built to make the atomic bomb. There existed, in 1940, an instrument called the mass-spectrograph. It operated somewhat on the principle of a cream separator, the slightly heavier U-238 being separated from the lighter U-235 by means of a magnetic field which affected them differently. But one single mass-spectrograph would have to be kept running 24 hours a day for about 12 million years to sort one pound of U-235 atoms from the necessary amount of purified metallic uranium.

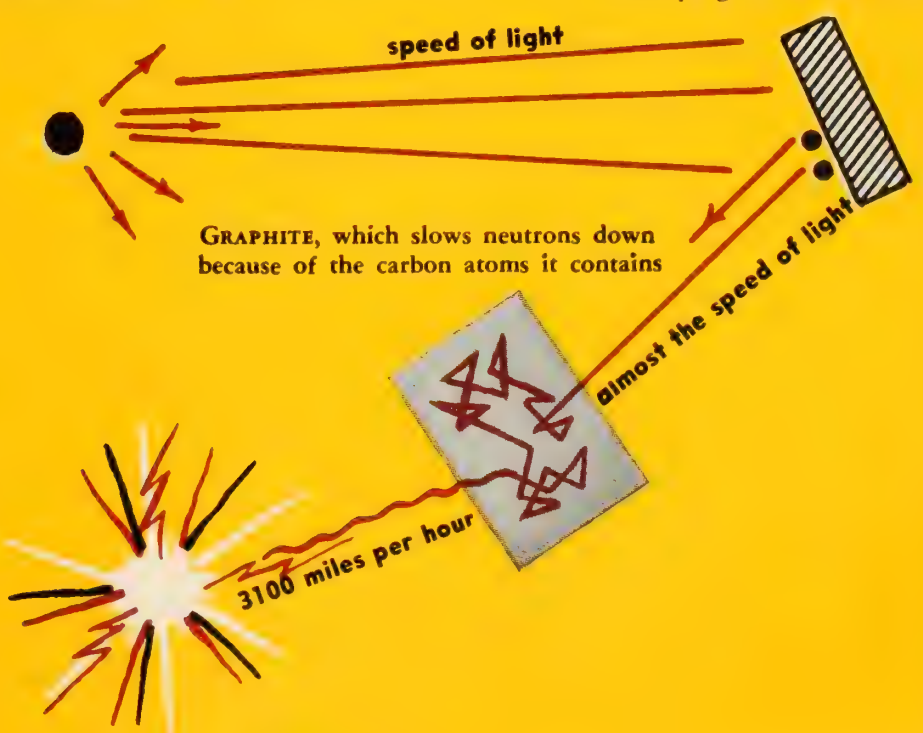
One way would have been to put 12 million machines to work and get a pound of U-235 in one year. To obtain a yearly production of 400



IT CAN now enter the uranium nucleus without racing through, and the uranium gives off four more neutrons which, however, are all fast

THE FIRST experimental "trigger" for U-235 then looked like this

BERYLLIUM, which when hit by the rays, gives off fast neutrons



U-235, HIT BY SLOW NEUTRONS, EXPLODES

pounds, the amount the Hiroshima bomb may have contained, would require 4800 million machines.

Another possibility (and this was purely hypothetical in 1940) was to do something with U-238 to *convert* it, in some manner, into some other material. Irradiation of uranium with neutrons produced a new uranium isotope, U-239, which does not exist in Nature. This decays into a new substance, called neptunium because the planet Neptune is *beyond* Uranus in the solar system. This substance was not stable. It changed into still another new substance called, for similar reasons, plutonium.

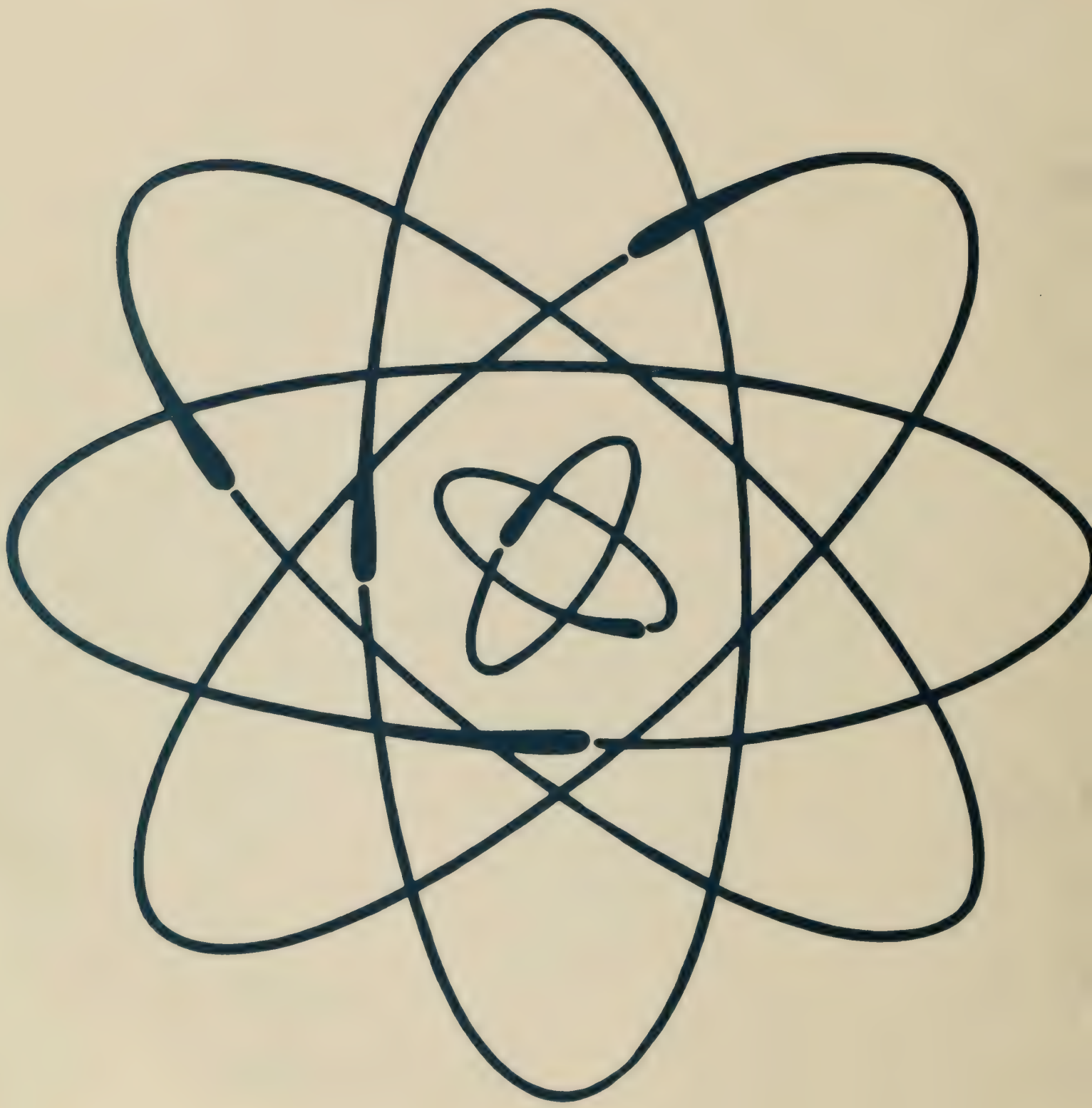
Plutonium, it seems rather certain, is stable to a certain extent and fissionable like U-235. But a difference is hinted at in a cautious report prepared by Prof. Smyth of Princeton University at the request of the War Department. Apparently plutonium fissionizes like U-235 when its mass is small, but once the mass approaches what has been called the "critical size," it will go into atomic explosion. This characteristic suggested an application that could be used in military operations. If enough plutonium to produce an atomic explosion could be kept in separate pieces, so that each piece were well below the "critical mass," and then could be brought together rapidly, the whole would explode with tremendous violence.

Part of the answer to the second problem—how to produce a chain reaction—is no secret. A fast neutron will bounce off a heavy atom without measurable loss of speed. But if it runs into a light atom, like a hydrogen or carbon atom, which has little more mass than the neutron itself, the bounce is mutual, and the two bodies share the original speed of the neutron. This means that a neutron which has been bounced around in a dense swarm of light atoms for a time will have slowed down enough to set off additional uranium atoms. In practical terms it means that the U-235 should be surrounded by a compound rich in hydrogen atoms, such as paraffin or simply water, or one rich in carbon atoms, such as graphite.

That should create a more or less fuel-like slow reaction, very useful for peaceful purposes, but not suitable for bombs. The method of setting off all the atoms at once remains one of the most closely guarded military secrets.

The bombs which helped to end the War prove that atomic energy can now be used at will. So far, we have only been able to explode the atoms of the rarer isotopes of uranium and its heavier derivatives. In appearance U-235 is a silvery metal, slightly softer than soft steel and about as heavy as gold. Gold has a specific gravity of 19.3, while that of uranium is 18.7. But having found the key to one element's nucleus, we'll probably find the keys to others' too. And the peacetime possibilities of atomic energy are even more boundless than its destructive power in war.

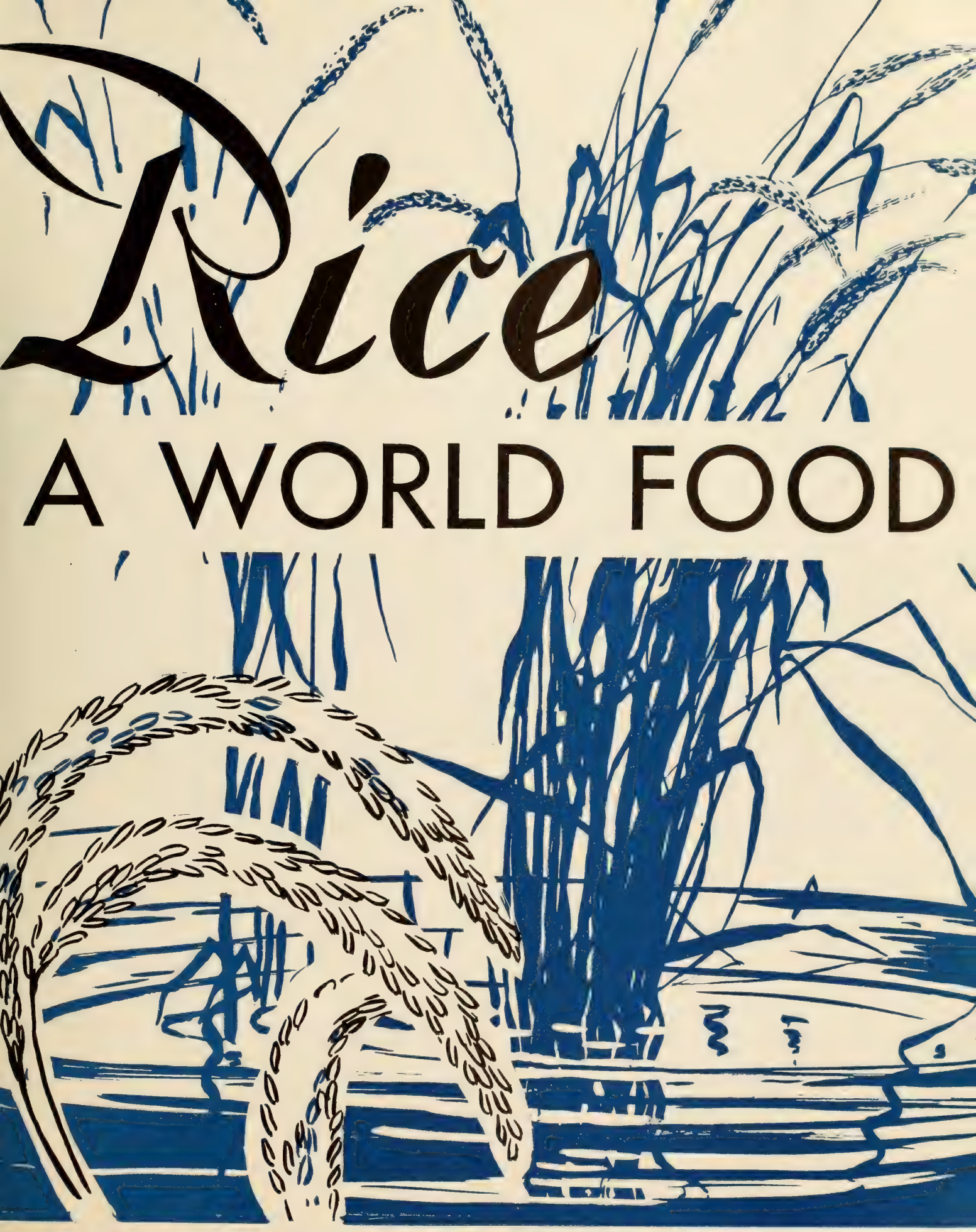




THE AMERICAN MUSEUM OF
NATURAL HISTORY, No. 120

Rice

A WORLD FOOD



By CLARK WISSLER

RICE AS A WORLD FOOD

By

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MAN AND NATURE PUBLICATIONS

Science Guide No. 121

THE AMERICAN MUSEUM OF NATURAL HISTORY

Central Park West at 79th Street, New York 24, N. Y.

Reprinted from NATURAL HISTORY Magazine, January 1946



◂ UNHULLED RICE KERNELS of the variety known as Blue Rose

▾ CULTIVATED RICE

Photos from U. S. Dept. of Agriculture

By CLARK WISSLER

Curator Emeritus of Anthropology, The American Museum of Natural History

Rice AS A WO

RECENTLY two articles appeared in this series stressing the importance of wheat and corn in the development of civilization. We now look at rice, the chief crop in the third great cereal area of the world. When the New World was discovered, corn characterized one such area as shown on the accompanying map. In the Old World we find two fairly distinct areas, a central area dominated by wheat, and a southeastern area devoted to rice. Wheat seems to have been first domesticated in Asia Minor, a dry upland country, whereas rice originated in a tropical, rainy, marshy country. The cultivation of each spread abroad rapidly about as far as its growing habits permitted.

The area devoted to the cultivation of rice is evidence of its importance to man. The number of people who de-

▾ CULTIVATED RICE in the field

Photo from U. S. Dept. of Agricu



One half of the people of the world consider rice their chief food. To examine its role in human life is to travel far back along the corridors of history

RLD FOOD

pend upon it for food is even more impressive. Almost everywhere in Southeast Asia, rice ranks as the main food. Because of the density of population in that part of the world, it is estimated that one half of the human race lives upon rice. The other half of the world's people occupy a much greater area, but for the most part they are bread eaters (wheat, barley, rye, and corn).

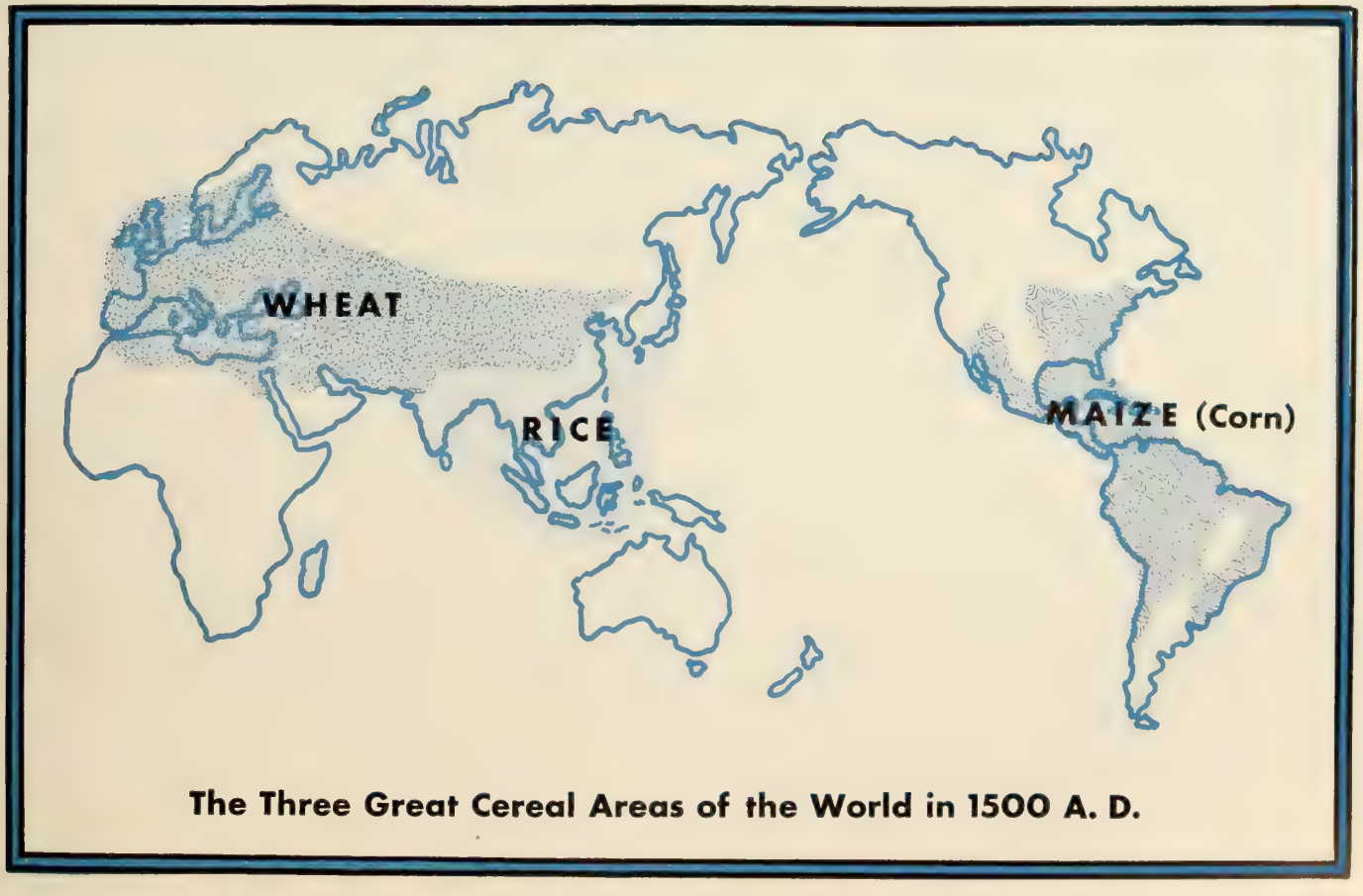
When we think of rice, we think of China, but in India rice plays an even larger role. British India alone, with a population of about 300 million, produces annually about 600 million bushels of rice. We have no good statistics for China with its 400 million people, but it is estimated that she produces less rice than India. Hence, it would be a mistake to rate China as a whole as being fully dependent upon rice, though rice is the chief food in the southern provinces.

In a region like the Philippines, native life is largely organized around the production of rice. Its importance is shown by the special rituals that accompany almost every phase of its cultivation and processing. It is the only food recognized by such ceremonies in the Philippines. As A. L. Kroeber expresses it in his well-known book,* "The native point of view is clearly that if the success of the rice is assured by the necessary magical and ceremonial means, other crops will automatically take care of themselves. When plant food is offered to the spirits in any connection, it is almost invariably rice. In short, the Filipino not only eats rice, but thinks in terms of rice, and if his civilization is to be described in a single phrase it can only be termed a rice culture."

**The Peoples of the Philippines,* page 86. (Handbook 8, The American Museum of Natural History.)

We have noted that there is still some difficulty in identifying the wild ancestors of wheat and corn, but cultivated rice seems definitely to have come from a single species, *Oryza sativa,* native to the East Indies. All rices grown are regarded as varieties of this species, and they are surprisingly numerous. According to some writers, about a thousand varieties of cultivated rice are known in India alone, all of which are special strains, adapted to local differences in soil, temperature, and rainfall. In the main, however, a tropical or at least a subtropical climate is required. The plants are annuals and reach a height of two to five feet, with panicles (seed heads) roughly resembling oats.

The original wild species required low ground that was flooded at least part of the year. The cultivated varieties known as "hill," "upland," or "dryland" rice can be nursed through the growing season without flooding, but the yield is less and the grains smaller than in the aquatic varieties.



The Three Great Cereal Areas of the World in 1500 A. D.



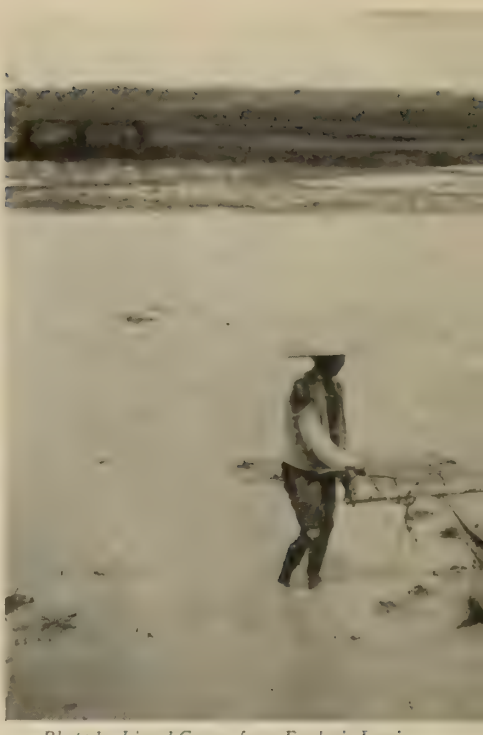


Photo by Lionel Green, from Frederic Lewis

▲ CULTIVATION OF RICE apparently came later in history than wheat. But wild rice was probably eaten in the East Indies long before the plant was domesticated. The only implements the first rice-growers used seem to have been digging sticks and wooden spades. Only after the cultivation of rice spread to the Asiatic mainland and contact was made with people who grew wheat and millet were the plow and draft animals adopted. "Dryland" rice, as distinct from that grown in flooded fields, was probably developed through watching wheat farmers at work

▼ WHEN the field is dry and the rice mature, knives or sickles are used to harvest it. A scene in Bali

Photo by Lionel Green, from Frederic Lewis



Methods of rice farming

One of the regions often chosen to best exemplify aquatic rice-growing is the Malabar coast of southwest India. This coast receives torrential rains in May, June, and July, followed by a period of moderately heavy rains in October. The dry season is from December to March. The



TER PLOWING, the wet rice field is smoothed
neans of a "scraper": a scene in Bali



A.M.N.H. photo

▲ TRANSPLANTING RICE. Sometimes the seed is sown broadcast, sometimes it is trampled into the mud. Here the young plants are being replanted, near Baguio in the Philippine Islands

lowlands of the coastal belt vary from 30 to 50 miles wide and are thickly populated by rice-growers. There are 1000 to 2000 inhabitants to the square mile. Originally these lowlands were covered with dense deciduous forests, which were later cleared for rice growing. All the land that can be flooded by impounding rainfall and river water is devoted to rice. Sixty to 120 days are required for a crop, depending upon local conditions. Harvest time is usually in September.

Before the rains begin, a simple pointed plow is used to scratch up the surface of the ground. Water buffaloes are preferred to oxen and are yoked to the plow either singly or in pairs. Cattle dung is spread over the plowed surface, which after the first rains is plowed once more, and the earth is finally smoothed by dragging a log back and forth.

When all is ready, the banks, or dikes, surrounding the field (paddy) are repaired. If the timing has been correct, the rains now begin, and as soon as the ground softens up, the rice seed is sown broadcast, sometimes trampled into the mud, sometimes not. The plants begin to grow in the water-covered soil. At intervals during the growing season, men and women wade into the rice paddy to pull out the intruding weeds. Finally, the water is drained from the paddy

▼ MULTIPLE SCARECROW: an arrangement of lines extending to all portions of the field and jerked as needed from a central tower. This device is used frequently in Hawaii. Constant vigilance is necessary to save the rice crop from birds

Sevda Studio photo







Three Lions photo

▲ A JAPANESE RICE GARDEN

◀ TREADING RICE IN THE PHILIPPINES: the aboriginal method of threshing the world's staple food grains
(Fenno Jacobs photo, from Three Lions)



➤ HEAVY WOODEN PESTLES are sometimes used in hulling rice in the Philippines

Theodore Roosevelt, Jr. Collection, A.M.N.H.

▼ THIS VIEW in a Chinese shop in the town of Pishan shows a method of hulling rice that has been in use for centuries

Alexanderson (C N S), from Guillumette, Inc.



to permit the ground to harden. When the rice is mature, the heads are cut from the stalks with various kinds of knives or sickles. Immediately thereafter, millet, pulse, or sesame is sown. Water buffaloes, a few cattle, and sheep and goats are herded upon the wastelands and are fed in part upon rice straw, chaff, and other crop foods, such as millet, oil cake, etc.

Turning from the Malabar coast-dwellers to Asiatic and insular rice-growers in general, we find that wherever the growing period is short, rice may be sprouted and grown for a time in flooded beds and then transplanted by hand to flooded rice fields. This naturally adds to the labor of rice production.

When the rice grains begin to mature, the fields are raided by seed-eating birds, often in such numbers as to leave but a small harvest. A common method of keeping the birds away is to stretch a number of strings across each paddy, with streamers or pennants attached to them. These flap about when the cord to which they are fastened is jerked vigorously. Small platforms or towers are erected so as to enable a single watcher to guard four plots. This is no small task, because the flock, when disturbed, merely takes wing to descend at another location.

Processing the crop

Threshing rice involves two operations. As in oats, a hull or husk firmly encloses each grain, and this must be removed by rubbing or gently beating the grain in a mortar or upon a mat. The most primitive way is to tread barefoot upon the unhulled grain.

The next step is to separate the detached hulls, or chaff, from the grain by winnowing. The usual way is to scoop the trampled mass into a shallow basket and toss it into the air above a mat or sheet. The heavy grain falls straight down, while the chaff is floated to one side by the gentlest of air currents.

For the most part the hulled grains of rice are not white but are covered with a coat of brown, which can be removed by rubbing or beating, a process called "polishing." However, many native rice-growers dispense with this procedure and eat "brown rice" instead. The food value of rice is decreased by polishing, yet custom regards white rice as preferable.

In the Philippines, as in many other parts of the rice area, hillsides are



Fenno Jacobs, from Three Lions

▲ BEATING RICE to separate the kernels from the husks, in the Philippines

utilized by the construction of terraces, or walled-in shelves, extending horizontally one above the other. These are flooded with water in the rainy season. The magnitude of these terraces, covering the landscape from valley to hilltop like a gigantic series of hanging gardens, is impressive. The prodigious task of keeping them in order means that the owners make rice-growing their chief concern. Hand labor prevails, with the simplest mechanical appliances, — little more than digging sticks, crude wooden shovels, and the bare hands. The plow, first developed by wheat farmers, seems to have been introduced by the Spanish conquerors of the Islands.

Since 1500 A.D. the cultivation of rice has been introduced into many tropical and semitropical areas, such as southern Europe and North Africa, and parts of west Africa, southern United States, certain localities in Mexico, Central and South America, and many Pacific Islands, including Hawaii. The annual production of rice in the United States is about 70 million bushels, or about one-fourth the barley crop. This amounts to about one-half bushel per capita, but since cooked rice expands 300% in bulk, the amount is of some importance.

North American wild rice

Our story would not be complete without some account of wild rice in America. This is a different genus of

▼ AFTER the rice is hulled, it must be winnowed. The kernels fall to earth and the chaff floats away

Alfred T. Palmer photo, from Black Star





➤ THE LABOR of tending hillside rice terraces like these and of keeping the dikes in repair can easily be imagined: a scene in Ifugao Subprovince, Luzon, in the Philippines, where human life revolves about the growing of rice

Theodore Roosevelt, Jr. Collection, A.M.N.H.

rice, *Zizania aquatica* and *Z. milicea*. *Aquatica* grows in single stems, five to ten feet tall, with panicles about two feet long. The glumes (husks) are about an inch long, containing long slender grains, of a dark slate color when ripe. The plants can adapt themselves to quiet water, two to eight feet in depth, preferably the margins of ponds, lakes, or flood plains of rivers with mud bottoms. Early in June the shoots appear above the water. They mature about August 1st, and the grain is ready for gathering in September. The early French explorers speak of this wild rice as wild oats, Indian oats, etc.

The plant is an annual and seeds itself, since the ripe grains are heavy and sink to the bottom when they fall. The main habitat of *Z. aquatica* is the part of the United States and southern Canada east of the 100th meridian west, an area roughly east of a line passing through Pierre, South Dakota, Dodge City, Kansas, and Abilene, Texas. The Indians who made the most use of wild rice were those of eastern Canada around the Great Lakes and Winnepeg drainage areas, tribes speaking Algonkin and Siouan.

A similar Asiatic species, *Z. latifolio,* has been observed in Siberia, Japan, Formosa, and part of eastern China. Although *Z. aquatica* is reported from the West Indies, it is not known in South America.

None of the North American Indians seem to have *sown* wild rice until after contact with white people. Since 1800, some of them are known to have stocked lakes and ponds when necessary, but once the plant was introduced, it needed no cultivation.

The only attention the early Indians gave the crop was to tie the rice heads in bunches to protect the crop from birds and to prevent the wind from shattering out the grains. For this, they made twine of basswood



WILD RICE, native to North America, was an portant source of food to many Indians. It urished without cultivation in the margins of kes and on the muddy floodplains of rivers d was harvested in September. (Potomac ver)

Fish and Wildlife Service photo

bark fiber. Each woman, or family, used a slightly different tie and accordingly claimed ownership of the ripening rice.

The rice was gathered from canoes, poled or paddled among the rice stalks, the bunches of heads being bent over and the grain beaten off into the boat, as shown in one of the illustrations. The earliest accounts of rice gathering (1689) mention tying the heads but make it clear that much of the rice harvested was not tied but merely bent over the edge of the canoe, as shown in the drawing by Eastman. When a canoe was filled, it returned to camp, where the load was spread upon drying-frames.

The grains had then to be hulled by treading or beating. According to tribal custom, there were varying stages in these processes, since the drying frames might be smoked, the grains parched in a kettle, etc. The wild rice you purchase from your grocer has a smoky flavor if prepared in the Indian way.

Note that the main procedures in preparing wild rice closely parallel those for cultivated rice in the Old World. The two important differences are that in Asia rice is not tied in bunches to protect it from birds as was wild rice in America, and it is not smoked. On the other hand the American grain is not polished. In both areas the laborious processes are harvesting, hulling, and winnowing the grain. Like the Asiatics, the Indians almost never ground their rice but ate it boiled, usually with meat of some sort and frequently sweetened liberally with maple sugar. The Indians did not plant and weed their crops, but the labor of making twine and tying their rice was by no means a light task. Gathering the basswood bark and preparing the twine by hand occupied the spare time of the family during the winter months. We have estimated that from two to six miles of twine were needed by each family, the number of bunches tied ranging from 400 to 1600.

A world view of man's plant foods

The plant foods of man are embraced under a few main classes, as (A) cereals, (B) root crops, (C) fruits, and (D) vegetables. The cereals, or grains, head the list: wheat, barley, rice, rye, oats, the millets, and maize. All are the seeds of grasses. It appears that the period during which man merely gathered the wild foods that nature offered at the time and place, without cultivating the plants, was by far the longest span of time in human existence. During this long primitive period man overran all the habitable parts of the earth and met up with almost every variety and species of seed-bearing plants. The opportunity for experiment was almost boundless. In turn, the habitats of these grasses were spotty and highly localized. By trial and error, man probably came to recognize the most important species of seed-bearing plants in his habitat and sought to devise more and more convenient ways of gathering, processing, and cooking them.

Even from the first he seems to have been a *gourmet,* putting himself to a bewildering routine of trouble and toil to improve the raw products offered by nature. His fellow creatures were content to take seeds as they found them, but not he, as in the words of the most ancient of sages, "He prefers to earn his bread by the sweat of his brow." Even the way of the savage is the hard way. Hours and hours of patient toil are given to the preparation of what is eaten in a few minutes.

Fortunately for us, not all peoples of the earth became civilized at once. The understanding of our subject is made possible by comparing the ways of the nonagricultural peoples with the civilized. Thus in the United States we can still observe Indians gathering seeds as they did centuries ago, particularly in the semidesert lands of Arizona, Utah, Nevada, and southern California. The Paiute tribes, armed with simple ingenious basketry devices, strip seeds from many species of wild grasses, winnow out the chaff, and store the tiny seeds for grinding into meal and eventually baking in cakes, or more frequently for thickening soups. Seeds of more than 50 species were gathered by the Paiutes alone, which about exhaust the list of local wild grasses. Civilized men and women will not bother themselves over such small returns for the labor involved.

In a large part of semiarid Australia, where there is sparse vegetation and grasses, it is not surprising that the natives recognize the food value of even the smallest seeds. They carefully gather and conserve them, grinding them between stones and making cakes with the meal. It should not be overlooked that arid lands also bear numerous root plants whose bulbs are dug out with digging sticks. This is true in Australia as well as in the habitat of the Paiute Indians. Thus the popular contemptuous name "Digger Indians" is said to have been applied to many tribes west of the Rocky Mountains because they were so often seen digging in the ground for food. Some Australian explorers have written that the ground around a native encampment was so upturned as to suggest that a drove of pigs had been rooting up the place. Even Captain Lewis (of the Lewis and Clark Expedition) found the Nez Percé Indian women who were camped along the Columbia River so busy pounding roots that the noise reminded him of a nail factory.

But we are now concerned with cereals or seed grasses. We have reason to suspect that a long period of experimentation with wild seeds was necessary before success was achieved in producing the world's three great staple foods — bread, (wheat, barley, and rye), hominy (maize, hulled by boiling in wood ashes), and a bowl of boiled rice. Partly because of the large role that grasses have played in providing food for man, the semiarid lands are more often thought of as the place where agriculture began. Many root crops seem to stem from forest flora, but not all of them do. Tree-crops are chiefly of forest origin, but man probably planted grains before he planted anything so slow-growing as a tree. Plants of aquatic origin, including rice, tend to have forest homelands, but grains of the millet-wheat group seem to have been native to uplands tending toward aridity. Further, their cultivation appears to have been more ancient than rice. It is therefore most probable that the cereals and civilization developed in favorable spots in a semiarid environment and that the development of rice was stimulated by the successful exploitation of wheat. These assumptions are at least consistent with the locations of the earliest known civilized towns of any size. Civilizations are not conceivable without relatively dense populations, which in turn depend upon agriculture.

The archaeology of agriculture

The archaeology of plant foods, wild and domesticated, is only beginning to unfold, but the world is awakening to its importance and there is promise of new knowledge, like the

➤ CHIPPEWA INDIAN in boat, tying wild rice. To protect the rice from birds and wind, the Indians laboriously tied the heads in bunches. Ducks of every variety, geese, and birds of all sizes and kinds found millions of acres covered with this pleasant food, while the Indians could gather but a small quantity, according to Mrs. Eastman, who described the aboriginal scene in 1853



Courtesy of the Bureau of American Ethnology



➤ A NARROW BED of wild rice tied in bunches or sheaves

➤ THE BINDING TWINE was threaded through rings attached to the jacket the woman wore when tying wild rice. From two to six miles of twine are estimated to have been needed by each family for tying one season's wild rice. Customarily the twine was made by shredding out long slender ribbons of basswood bark fiber and tying them together (From the Chippewa Indians)

Photos courtesy of the Bureau of American Ethnology



WHEN THE WILD RICE was ripe for harvest, he grain was beaten into canoes as shown in his drawing by General Seth Eastman, dating om the middle of the last century. To quote om Mrs. Eastman, the girls from an Indian village made quite a frolic of it

Eastman's Aboriginal Portfolio





◀ THE PROCESSING OF WILD RICE in America was in many ways similar to that of cultivated rice in the Orient. Here we see a Chippewa Indian treading rice in the familiar manner to remove the husks, but with two railings to take some of the weight off his feet

Courtesy of the Bureau of American Ethnology

▼ WILD RICE from the country of the Ojibway Indians: above, threshed but not hulled; below, hulled and ready for storing or cooking

A.M.N.H. photo



twilight before a glorious dawn. Within another decade or two those who survive us will write a thrilling account of this new chapter in the science of man. Even now scraps of information are worth citing. We recall one of the latest contributions to the knowledge of plant foods of early man. Most of you have heard of that famous cave in China in which were found the remains of Peking Man. Embedded in the debris of that cave were masses of cracked shells of seeds which botanists have identified as hackberry (genus *Celtis*). A modern form, *Celtis occidentalis* var. *crassifolia,* still grows in western United States, especially in semiarid districts. Similar hackberry seeds are found in deposits of the Pleistocene or Ice Age in South Dakota and in north China. The mere presence of the cracked seed shells in the cave does not prove that they were eaten by man. Rodents could have carried them into the cave. However, Ralph W. Chaney of the University of California sought to solve this problem in a scientific way. He offered modern hackberry seeds to rodents and monkeys of several different species. Most of the rodents ignored them, but the few that ate them merely gnawed small holes into the shells to extract the kernels, whereas the shells in Pekin Man's cave were crushed to fragments. The monkeys chewed the seeds and spat out the shell fragments, which were similar to those in the cave, but there is no archaeological evidence that monkeys lived in the vicinity of the cave when Peking Man was there. Since even modern Indians in western United States eat hackberry seeds, Professor Chaney gathered information from them. He found that their method was to crush the seeds between stones to secure the kernels and that the resemblance of these fragments to those from the cave approached identity. We do not know whether Peking Man chewed the seeds or crushed them between stones, but since he used simple stone tools, it seems fair to assume that he gathered hackberry seeds and carried them home to crack at his leisure.

Diggings by archaeologists almost everywhere have brought to light the charred remains of grasses and seeds, and botanists have usually been able to identify them. In the previous articles on wheat and maize we have mentioned such findings. In the submerged remains of Swiss lake dwell-

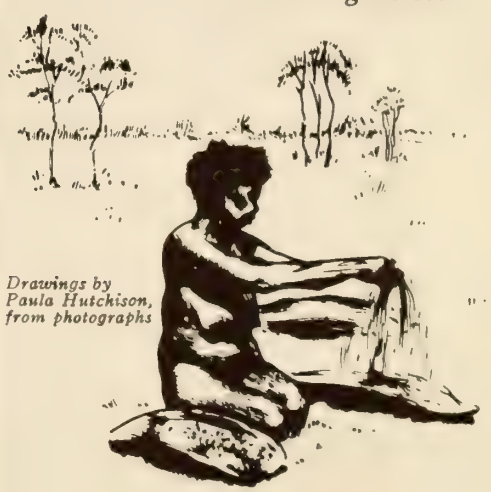
➤ ALL of the world's modern production of wheat, corn, and rice has grown out of the primitive occupation of collecting grass seed. Today we can still see this elementary activity among the naked, hungry Australian "blacks," as shown in these drawings. For thousands of years, primitive women have thus gathered food—a seed or two here, another there—at great cost in toil and patience and with a return so trifling as to transcend belief



▼ ILIAWRA women in Australia collecting grass seed from ants' nests



▼ TREADING the grass seed to husk it



WINNOWING the husked grass seed

Drawings by Paula Hutchison, from photographs

THE SIMPLE but exacting routine of converting grass seeds to food is everywhere the same: (A) find the ripening seed, (B) strip the grain from the stem, (C) hull it by treading, (D) winnow out the chaff, (E) pulverize the seeds, (F) combine with water to form a paste, (G) bake or toast on a fire

ings were found charred and natural remains of many cultivated plants, including wheat, barley, rye, oats, millet, celtic peas, and carrots. By such finds it has been possible to distinguish between the horizons of agricultural and nonagricultural peoples.

In the New World we now find special published articles on the prehistory of cotton, beans, peanuts, sunflower seeds, gourds and squashes, tobacco, maize, etc., each a fascinating chapter in the unwritten history of the world. One conclusion to be drawn from such data for the United States is that other kinds of agriculture were practiced in Kentucky, Tennessee, Missouri, and Arkansas long before maize was introduced into that region. In fact, the last crops to appear were maize and tobacco. Long before they were grown, sunflowers, squashes, gourds, and seed plants were a part of the agricultural economy of the tribes. A recent publication by George F. Carter* tells how the new data resulting from preserved seeds and fragments of the *Cucurbita* (gourds, squash, pumpkin, etc.) suggest that their cultivation in southeastern United States long preceded maize in the same area and that they found their way in pre-maize times into New Mexico and Arizona. In general, this new information fully justifies the belief that agriculture in the New World was developed independently and without influence from the Old.

Our younger readers can look forward confidently to the time when a much more complete story of man's achievements with plant foods can be written.

**Plant Geography and Culture History in the American Southwest,* Viking Press, 1945.

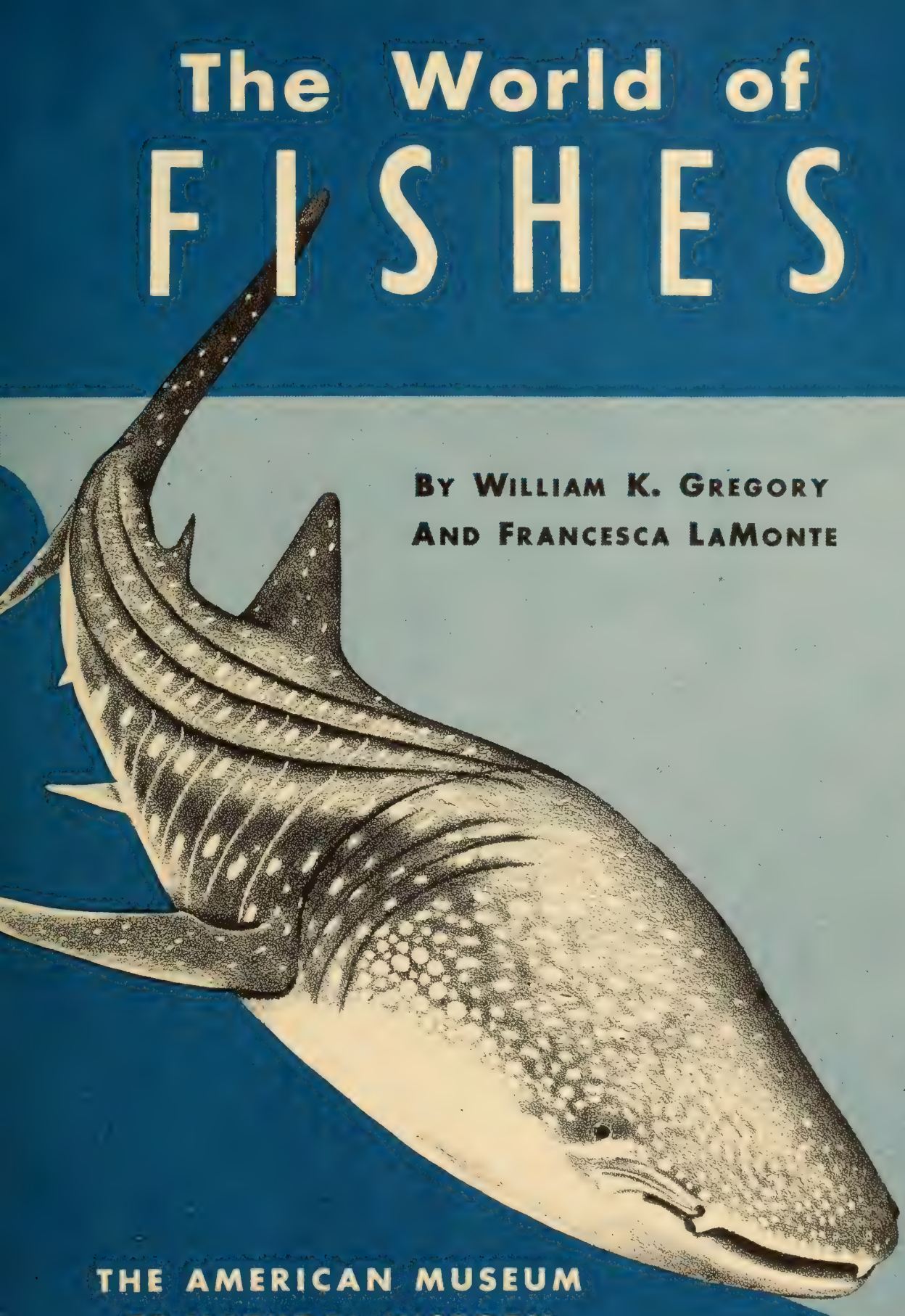
▼ A SEED-GATHERING BASKET AND BEATER from the Paiute Indians of Nevada. The basket is shaped so that the edge can be held low and the grass stalks bent over it and shaken by the beater. Again, the beater may be used to catch falling seeds and transfer them to the basket

A.M.N.H. photo



The World of FISHES

By William K. Gregory
And Francesca LaMonte



THE AMERICAN MUSEUM
OF NATURAL HISTORY

The World of Fishes

The world of FISHES

A SURVEY OF THEIR HABITS, RELATIONSHIPS, AND HISTORY, AND A GUIDE TO THE FISH COLLECTIONS OF THE AMERICAN MUSEUM OF NATURAL HISTORY

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and Museum Secretary for International Game Fish Association Affairs
The American Museum of Natural History

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↓ Fisherman in the native market on the beach at Cabo Blanco,

Photograph by Michael Lerner Chile-Peru Expedition, American Museum of Natural History, 1940



Introduction



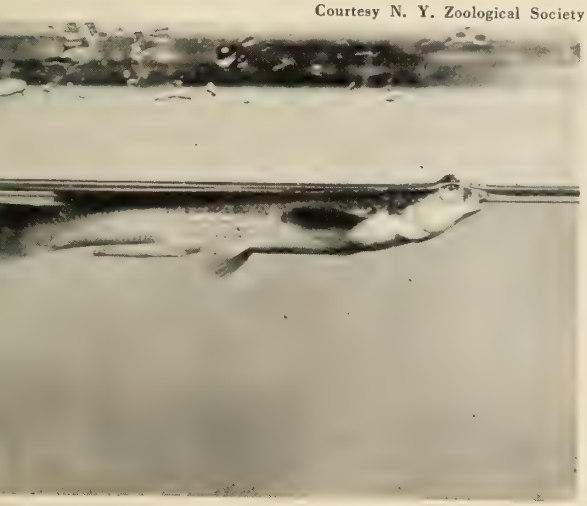
←Remora, the Shipholder: a small fish for centuries believed capable of stopping ships in their courses. (After Camerarius, 1654)

FISH STORIES have been told by romancers of all ages, and a public that loves to be humbugged has greedily believed them. Ancient, and equally astonishing, are the tales of the mermaid, the sea-serpent, and the giant Devilfish that threw its slimy tentacles around a Chinese junk. The myth of the Shipholder lasted from Aristotle's time to the end of the Middle Ages, and prominent roles in ancient naval encounters were assigned to this small fish which, by means of the adhesive disc on top of its head, was said to "bridle the impetuous violence of the deep" and stop large vessels in their course.

But man's puny imaginative efforts are put to shame by nature's own inventions. There is in reality a deep-sea Anglerfish in which the female is a thousand times heavier than the male who hangs like a pendant from the cheek of his huge mate. There are "four-eyed" fish equipped for vision both above and below the water line; fishes fully furnished by nature with rod, line, hooks, and angling bait; fishes carrying high voltage electrical equipment, fishes that hop about on land, and fishes that drown without atmospheric air!

All these oddities are included in the exhibits in the American Museum of Natural History. The main object of the exhibits, however, is not to place emphasis on the

Courtesy N. Y. Zoological Society



←The Four-eyed Fish (*Anableps anableps*), which is equipped to see above and below water at the same time

peculiar, but to show fish life in its most typical phases. In the Hall of Fishes of the World, there is a representation of the more important families to which the 20,000 known species of fish belong. They are classified and arranged according to their natural relationships with one another, and a number are exhibited in settings showing their natural habitat and life history, their commercial use, and their value to the angler.

The Bashford Dean Exhibit of Fossil Fishes is concerned with fishes of past ages, including some of the ancestral forms from which the fishes of the present time have descended.

We have frequent requests for "a book dealing with every known kind of fish in the world," but there is not and probably never can be such a work, although there are hundreds of books and papers dealing with fishes of particular countries and regions and with the many wonders of fish life. A short list of books cannot be inclusive, but the few references given at the end of this book may be found helpful.

One of the Oceanic Anglers, *Linophryne*, with luminous "headlight" for attracting its prey

A.M.N.H. photograph



The Biology of Fishes

Spawning

Fishes reproduce themselves by the union of two germ cells, one from the female, the other from the male parent. The female germ cell is the egg, or *ovum;* the male germ cell is the sperm, or *spermatozoon.* The two parent cells unite to form a single cell which is the fertilized egg, or *zygote.*

The egg is fertilized by the male element, which starts the process of development. But the male cell does much more than this; it brings with it all the hereditary tendencies derived through the father. The egg carries the hereditary tendencies derived through the mother.

INTERNAL FERTILIZATION: In some of the sharks, and in a few of the bony fishes, fertilization of the female's egg by the male sperm takes place within the body of the female fish after mating. The egg develops inside the female's body, and young fish are born.

In some other fishes there is internal fertilization, but the eggs are deposited in the water as eggs, and develop and hatch there.

EXTERNAL FERTILIZATION: In most of the higher fishes there is no introduction of sperm into the body of the female fish. In the mating act the eggs and sperm are simultaneously discharged into the water, and there the eggs develop and the larval fishes are hatched.

TYPES OF EGGS AND OF DEVELOPMENT: The eggs of sharks and rays are large and contain a large quantity of yolk. They are few in number and are normally covered with a horny shell secreted by the walls of the egg duct. In oviparous, or egg-laying, sharks, such as the European Dogfish, these eggs are laid, and the young, after a long time, hatch out from them. In many other sharks, however, where the young are long retained within the enlarged egg duct, the egg shell is either broken down or absorbed within the female parent's body, and the

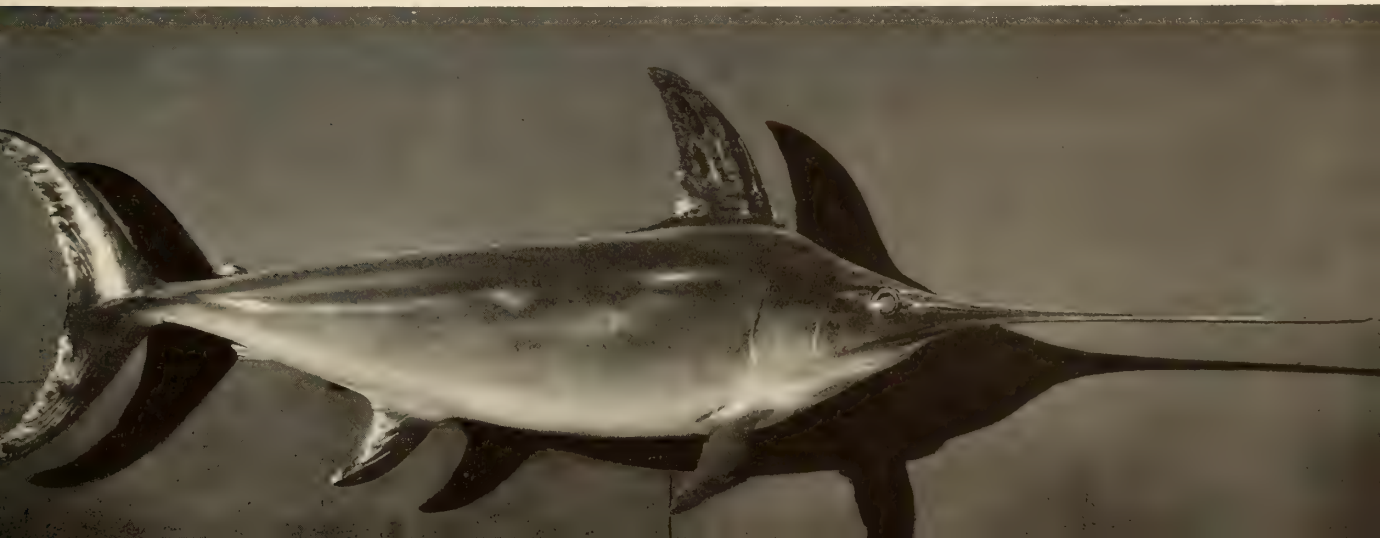
➔ Larval Swordfish 2½ inches long, taken in the Straits of Messina

From Sanzo, 1930



➘ Adult Swordfish weighing 601 pounds, caught off Louisburg, Cape Breton Island, Nova Scotia

A.M.N.H. photograph



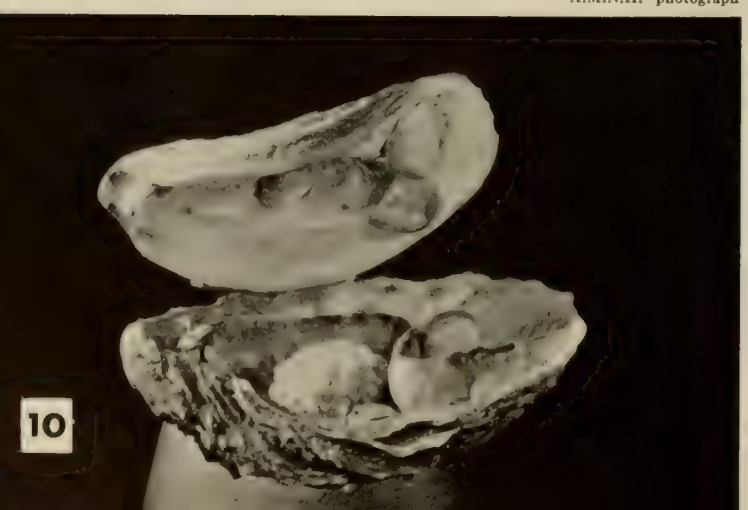
young are born in an advanced stage of development rather closely resembling their parents in general appearance and in feeding habits.

The opposite extreme is the method seen in most bony fishes, in which the eggs are very small and great numbers of them are deposited. After fertilization of the egg, the development of the embryo begins, and the fish finally reaches a free-living larval stage. This stage differs markedly from the parent fish in its small size, general appearance, and feeding habits.

The actual development within the egg shows marked differences from one group of fishes to another. One type of development is illustrated in the chart opposite, which pictures some of the successive stages in the development of the Australian Lungfish, *Epiceratodus forsteri.*

The first stage shows the fertilized egg, which is about one-eighth inch in diameter. The lower part of the egg is filled with yolk. In the next stage the egg has divided into halves. In the succeeding stages this process of subdivision continues until many millions of cells result. The general outline of the embryo is beginning to be visible in number 7; the head is at the left. In number 10, we note the already swollen brain. The heart, muscle segments of the body, and the segments of the spinal column are also indicated. The young fish is shown in number 13. Number 14 represents the adult.

A.M.N.H. photograph



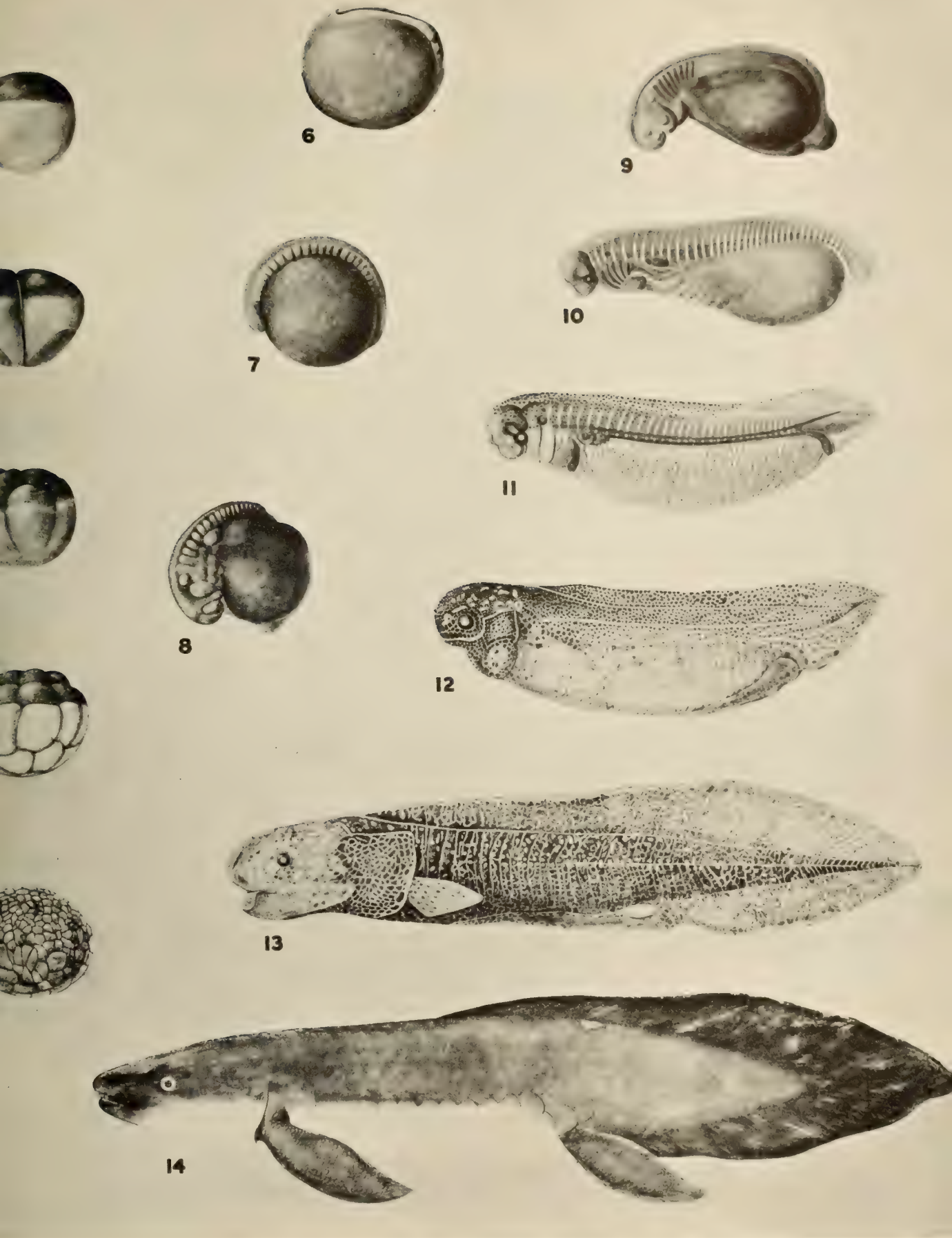
Eggs discharged into the water may either float or sink; the former are known as pelagic eggs and the latter as demersal eggs. No pelagic egg is very large, and they are often less than a millimeter (one-twenty-fifth inch) in diameter. They are transparent and often contain a large globule of oil. Such eggs are produced in countless numbers by fishes of many families—cods, flounders, mackerels, etc.

Some of the demersal eggs reach a larger size. Those of the salmon, for example, are about 5 millimeters (three-sixteenth inch) in diameter. In many demersal eggs the outer egg membrane is viscid and adhesive, so that the eggs readily stick to one another or to rocks, stones, or bits of seaweed.

Parental Care

In many cases among the bony fishes one or both parents, instead of abandoning their progeny to be the sport of the elements and the prey of innumerable enemies, either construct a nest, as in the case of the Bowfins and the Sticklebacks, or in some other way guard and protect the young. The eggs may be deposited in some secure retreat, as in old oyster shells. Among the Sea Horses, the males receive the eggs in a brood pouch of skin beneath the abdomen, where they undergo their development. In the Cichlids and certain catfishes, one or the other parent takes the eggs in its mouth and does not eat again until the young are large enough to be released safely. In such cases, the number of eggs produced at one time may be small, since the parental care greatly improves the chances of survival for the offspring, while the individual eggs may be large.

← Eggs of the Gunnel, *Pholis*, deposited in an oyster shell and guarded by the parent fish (From a model in the Hall of Fishes of the World)



A.M.N.H. photograph. From wall painting by W. Benckert, after Semon

Development of the Australian Lungfish (*Epiceratodus*) from egg to adult

The Economic Pyramid of Fish-Eat-Fish

(From J. T. Nichols: "Remarks on Size in Fishes," *Marine Life*, 1944, vol. 1, no. 2, page 5.)

"One aquatic species preys upon another in a chain expanding downward from the predaceous monsters of the deep to the microscopic diatom. The diatoms are plants and can subsist on inorganic matter plus sunlight. Looking at it the other way around, the diatoms are so abundant that they support the whole great pyramid of sea life with the largest predators at the top. It will be seen at once that the nearer the base of the pyramid, the more abundant the potential food supply. By reaching several steps downward to the diatoms themselves, the menhaden nourishes its swarms, which persist due to their very bulk. There is analogy between the case of the menhaden and that of the very largest fishes, basking shark (*Cetorhinus*) and whale shark (*Rhineodon*). These are not predaceous, but strain rather small creatures from the water with their meshwork of highly developed gill rakers, and are thus able to support an individual bulk which renders them immune from attack.

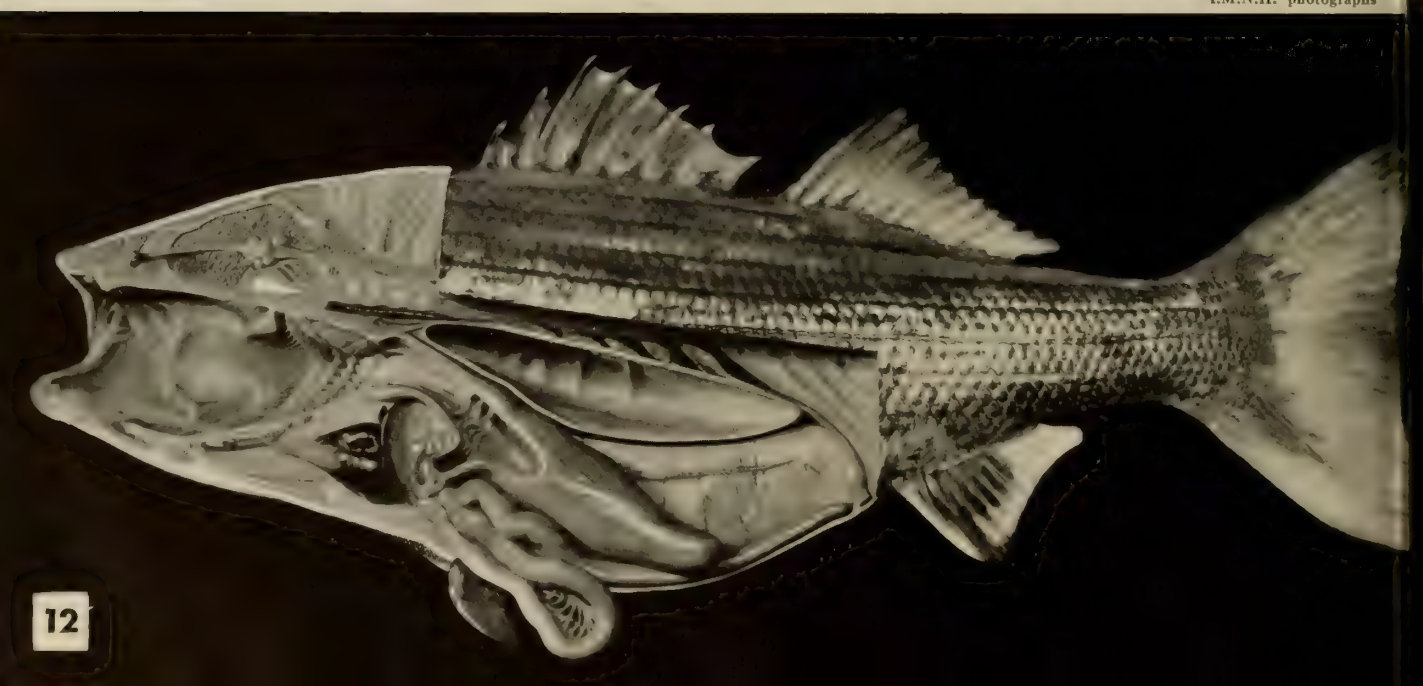
"It is logical enough that as the predators grow larger and larger, at higher and higher levels in the pyramid, they must grow fewer and fewer, and that this places a limit on their size. . . ."

Locomotion of Fishes

ENGINES OF THE FISH'S BODY: As a living, self-directing machine, the fish needs all the complex apparatus shown in the accompanying illustrations. Its jaws, mouth, and digestive system capture and prepare its fuel. Its heart and circulatory system (below) distribute the fuel to its engines and propellers, the muscles and fins, (opposite). By means of the oxygen absorbed by its gills from the water, it consumes the fuel and releases the necessary energy, which is expended in driving the body forward and is lost in the form of heat.

Engines of the Fish's Body: a model of a Striped Bass (*Roccus saxatilis*). Here are seen the organ systems for the capture and utilization of foods and fuel, and those for control and direction

A.M.N.H. photographs



Millions of delicate sense organs—tactile nerve endings, taste buds, lateral line organs, etc.—are constantly recording the changes in the surrounding medium and in the position of the various parts of the body, while the nose, eyes, internal ears, brain, and spinal nerve cord also act as an automatic control or steering system. The fish's framework, the skeleton, consists of a system of jointed levers and supports.

The greater part of the body of the normal fish is occupied by the locomotor machinery. This, in brief, consists of a close-set series of zigzag muscle segments running along the sides of the body from the head to the tail, making undulation possible. The fins act as keels, rudders, and brakes, and partly as paddles.

TYPES OF LOCOMOTION:[1] The Eel and the Trunkfish illustrate two extremely different methods of locomotion. The Eel has many joints in its backbone and just as many zigzag muscle segments on the sides of the body. By means of these, the Eel throws its long, slender body into a series of small waves, which pass backward faster than the fish moves forward. The Trunkfish, on the other hand, has a rigid body which swings from side to side with a sculling movement of its flexible tail.

Almost exactly between these two extremes stands the type of motion illustrated in such fishes as the Crevalle, or Horse Mackerel (*Caranx*). The fish's body is short, but not rigid. The movement is essentially the same as in the Eel, except that only one large curve can be formed at a time.

These superficially very different modes of locomotion are actually all based on the same dynamic principles, and the driving muscular action is relatively the same.

STREAMLINE BODY FORMS: Ships, submarines, torpedoes, airplanes, etc., are designed and built with "streamline" bodies so that they can slip through water or air with the least resistance. The typical fish body has streamline contours. The proportions of the body, however, vary enormously in different fishes, that is, the length in

[1] For a detailed article, see C. M. Breder, Jr.: "The Locomotion of Fishes," *Zoologica* (New York Zool. Soc.), 1926, vol. 4, no.5, pages 159-297.

This model shows the muscular system which generates and supplies locomotion, and the jointed skeleton which supports the muscles



relation to the height and the width, and the relative size of any single part such as the jaw or any one of the fins. Between any two extremely unlike body forms there are many intermediates.

Amphioxus, a Stem Chordate

The Lancelets are small, fishlike creatures from 1½ to 3 inches in length. They live mostly in the tidal zones of the warmer seas. They swim quickly and dart into the sand, drawing in water through the mouth, and extracting from it microscopic food particles.

Their anatomical structure is greatly simplified as compared with that of typical vertebrate animals, and they have generally been regarded as the most primitive of all known chordates.

The anatomy of *Branchiostoma*, one of the *Amphioxus* group, is shown in the photograph opposite depicting two of the remarkably accurate and beautiful models made by Dr. G. H. Childs which are exhibited in the American Museum.

The ground plan of the anatomy includes three parallel tubes, one beneath the other. The upper, or dorsal, tube is the nerve cord; the middle one is the notochord or central axis; the lower tube is the gut, or digestive tract. In the middle part of the body on either side of these tubes are rows of contractile muscle segments. In front, the gut connects with the greatly expanded pharynx, or gill chamber, including a great number of gill-bars, bearing blood vessels.

The name "Amphioxus," meaning pointed at both ends, was given because the notochord is continued forward to the front tip of the body. There is reason to believe that the extreme simplicity of the brain and total absence of a brain case may be the result of degeneration. The excretory organs are of an exceedingly simple type and consist of separate "nephridia," not combined into a kidney.

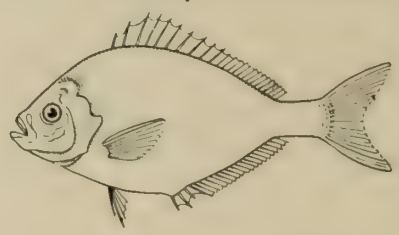
The right and left sides of the animal are not quite symmetrical, due to the crowding of the embryonic branchial pouches.

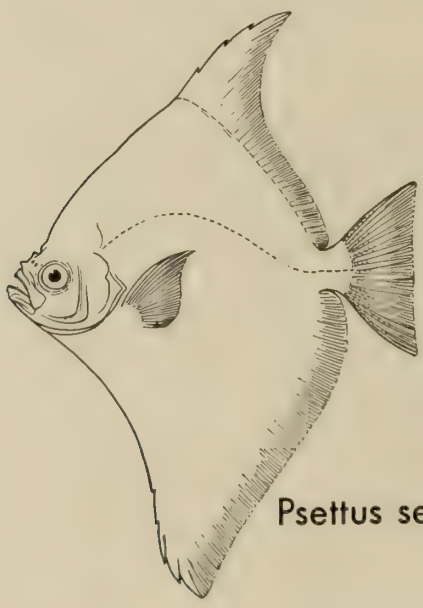
On each side, longitudinal folds of the body grow downward and meet below, forming an atrial chamber which encloses the branchial openings and has complex relations with the coelom or peritoneal space.

Two extremes of body form —very long and very high— and a primitive intermediate

From W. K. Gregory

Scorpis lineolatus





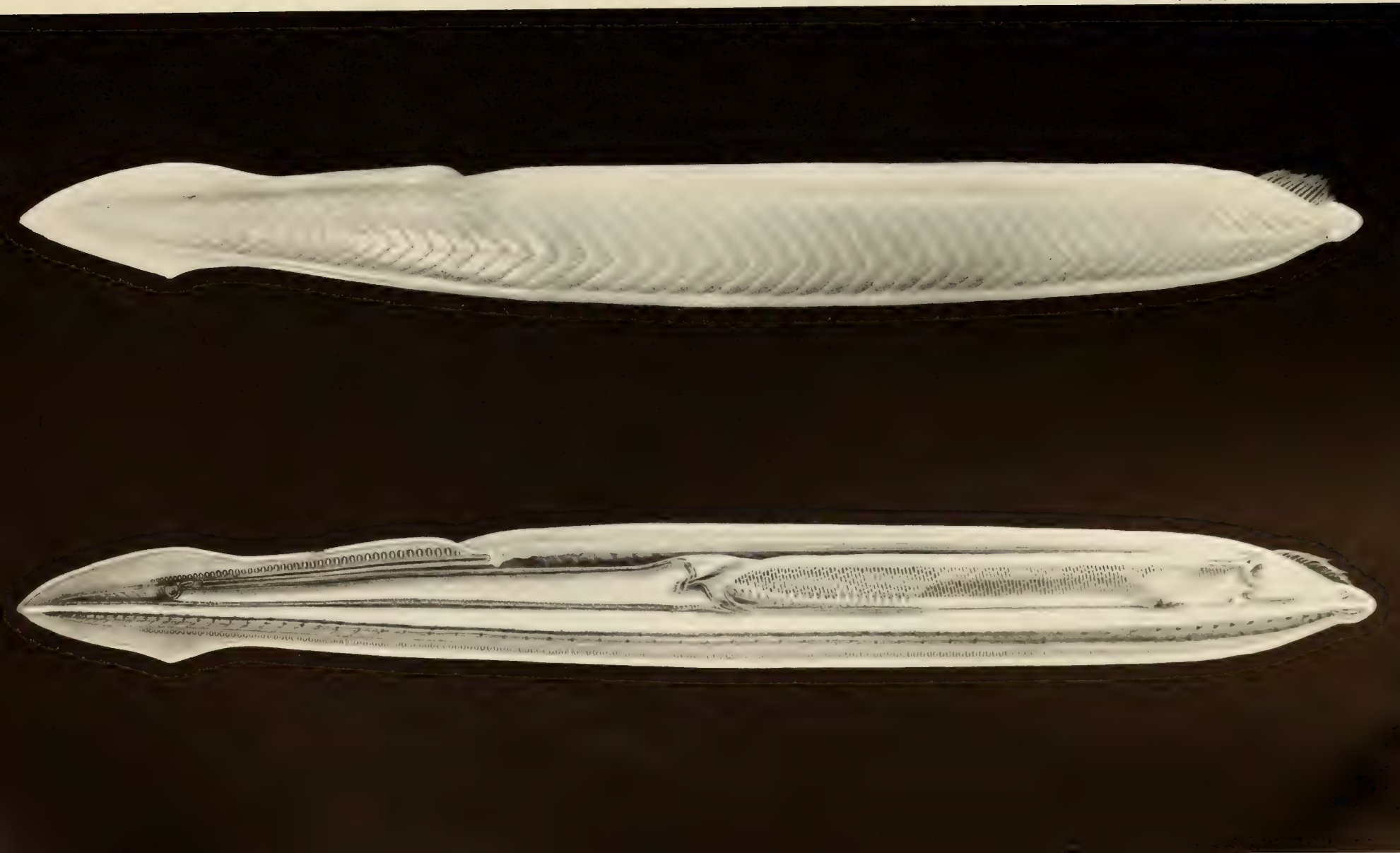
Psettus sebae

Ptilichthys



Among living animals, the Lancelets represent the earliest relatives of the fishes. These enlarged models show the internal anatomy and the musculature of *Branchiostoma,* a member of this group

A.M.N.H. photographs



Archaic Fishes

(Lampreys, Sharks, Rays, Lungfishes)

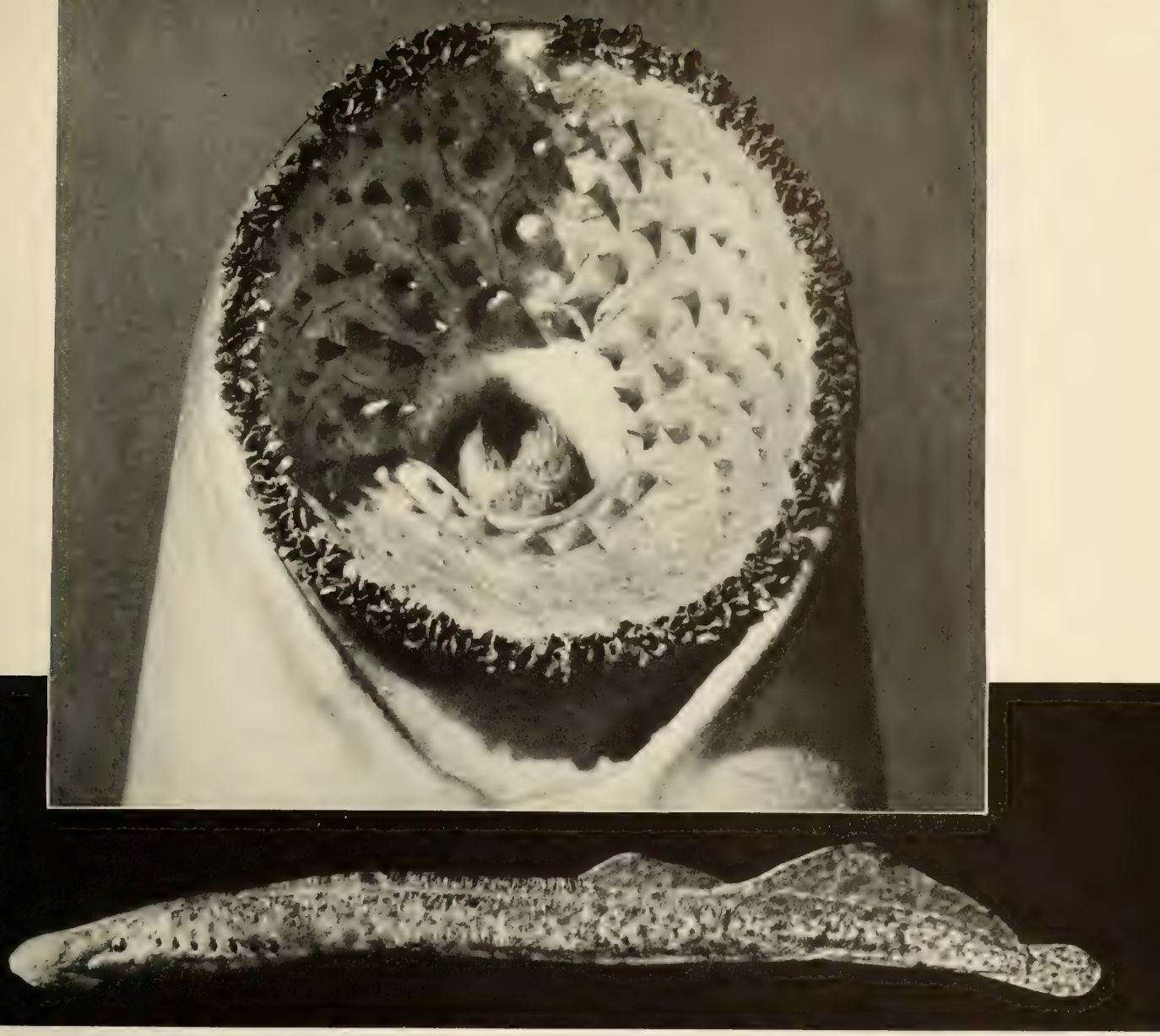
Lampreys and Hags
(CYCLOSTOMES)

This class, the Cyclostomata, includes the two groups of fishes known as the Hags and the Lampreys, eel-like forms with round, jawless, sucking mouths and rasping tongues. With these weapons, they fasten themselves on larger fishes and feed upon them. From the numerous mucous pits along the sides of the body, they secrete a gelatinous substance which swells into a jelly on contact with the water.

These creatures appear to be the highly modified and degraded descendants of the Ostracoderms, the oldest known forerunners of the backboned animals, but the intervening stages are missing from the record.

The Sea Lamprey comes from the sea into fresh water to spawn. As is shown in a group in the American Museum's Hall of Fishes, it roots up and pushes about the pebbles of clear, shallow streams in order to make a nest in which the eggs may be deposited and fertilized.

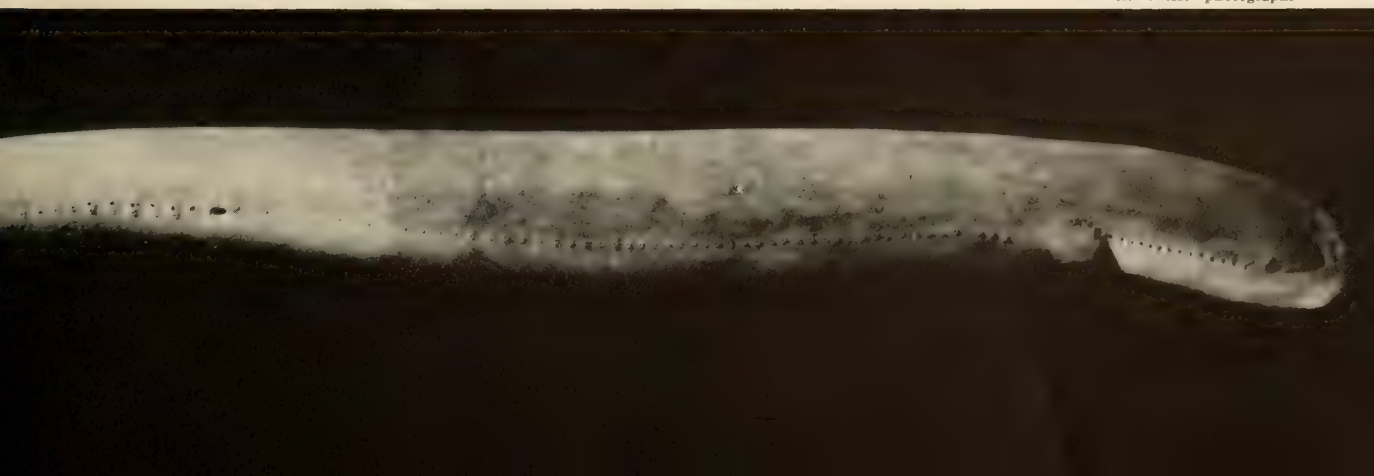




← A vampire of the sea with illustrious lineage. he modern hagfish is a "die-hard" that has retained any primitive features and survives today as a ritable living fossil. It lacks the true jaws of mod- n fishes, and in place of a backbone it has an astic notochord. But it has a full kit of burglar tools r rasping a hole in the side of a fish and sucking t its blood

↑ Another living fossil is the lamprey, likewise shown in front and side views. Its efficient suction disc has permitted the lamprey to survive down to the present in spite of its refusal to adopt a modern body design. Lampreys are erroneously called eels. In the tree of life they are further from eels than eels are from man

A.M.N.H. photographs



Sharks

The Sharks of the present are the survivors and descendants of those that lived many millions of years ago in the Devonian age of the earth's history (see Fossil Fishes, page 85). They differ from ordinary fishes especially in the gristly or cartilaginous state of the skeleton, which is not strengthened by bony tissue but by deposits of calcium carbonate and calcium phosphate. The skeleton as a whole is in a primitive or generalized state as compared with that of higher vertebrates, and the same is true of the brain, blood vessels, digestive system, etc. Hence a study of the anatomy of the Shark forms an excellent introduction to the anatomy of the higher vertebrates, including man.

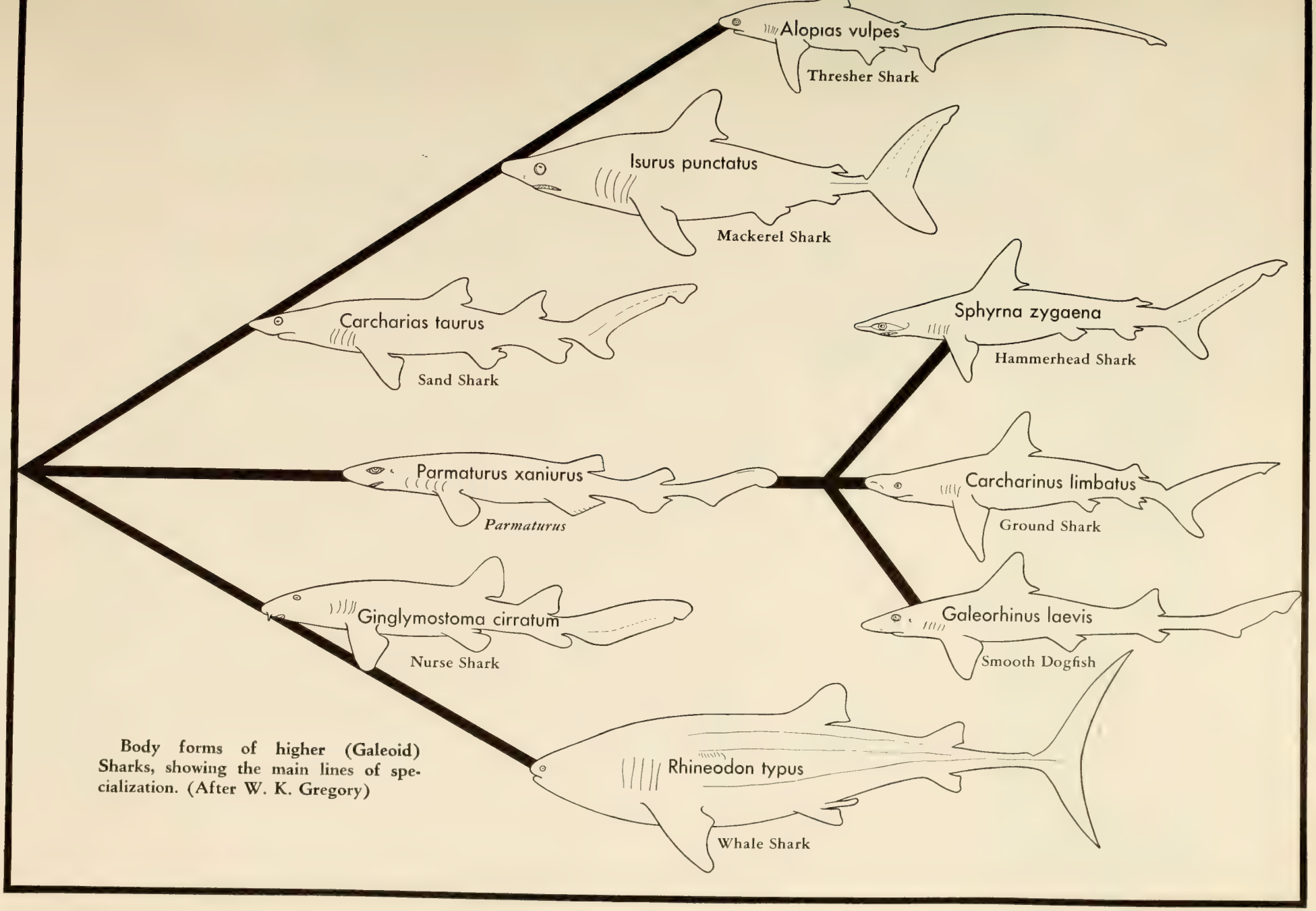
The adjacent diagram attempts to visualize the evolution of the body forms of the higher Sharks from some ancient central stock which is most nearly typified by the existing Sand Shark. Each figure stands for a family or group of related forms, and the branching of the lines indicates the relationships.

The Port Jackson Sharks (Heterodontidae): During and before that ancient period of the earth's history in which the vast swamps and forests of Pennsylvania were accumulating their stores of coal-forming vegetation, the shallow seas of the world swarmed with ancient Sharks, many of which bore curved spikes on the front margins of their fins. The more specialized forms of these early Sharks became extinct, but one family survives—the Port Jackson Sharks—and is still found living in the Pacific Ocean. These Sharks retain the stout fin-spines and whorled crushing teeth of their vastly distant ancestors. They lay eggs that are enclosed in a spirally twisted egg case.

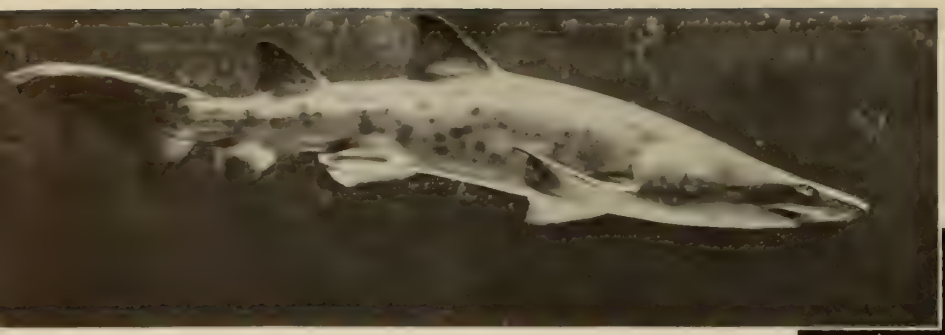
The Sea Rovers: an undersea scene showing sharks attacking a Sea Turtle. In the lead is a 12-foot Tiger Shark. On the left is a Hammerhead, and in the background, the White, or Man-eater Shark

From F. L. Jaques' painting of a group in the American Museum. A.M.N.H. photograph





Body forms of higher (Galeoid) Sharks, showing the main lines of specialization. (After W. K. Gregory)



←Sand Shark (*Carcharias littoralis*) in the New York Aquarium

↓Nurse Shark (*Ginglymostoma*) in the New York Aquarium

Courtesy of N. Y. Zoological Society



The Spiny Dogfishes or Squaloid Sharks (Squalidae): These are far removed from the higher Sharks and appear to be related to the ancestral stock of the Rays. They have lost the anal fin. Their teeth are usually closely packed and more or less uniform. Some of the deep-sea members of the family are only a few inches long, while the Greenland Shark is said to reach a length of 24 feet. In the common Spiny Dogfish, the eggs are surrounded by a horny shell, which breaks down within the egg duct. The young are born in an advanced stage of development.

The Japanese Sawsharks (Pristiophoridae): In both the Sawfishes (Pristidae) and the Sawsharks, the nose is produced into a very long, flat rostrum, armed on each side with a row of teeth. In the Sawfish, these teeth are stout and strong and the fish has been known to reach a length of well over 14 feet and a weight of over 700 pounds. The Sawshark, on the other hand, is a smaller fish with much smaller, sharper teeth, a smaller tooth alternating with each large tooth. A comparative study of the skeleton and internal anatomy of these fishes shows that the Japanese Sawshark is more nearly related to the spiny-finned sharks, while the true Sawfish is closely related to the Guitarfishes. In other words, the saw-toothed rostrum has been acquired independently in two distantly related groups.

The Notidanoid Group: This group includes the long-bodied deep-sea Frilled Shark (*Chlamydoselache*), the Cow Sharks, and their allies. These have only one dorsal fin, and not less than six large gill clefts. The Frilled Shark has trident-shaped teeth, but in the Cow Sharks and their allies the lower teeth are sawlike. They lay eggs with very large yolks.

The True Dogfishes and Cat Sharks: These widely distributed Sharks are variously called Scylliidae, Scylliorhinidae, and Catulidae. As in all the higher Sharks, there are two dorsal fins without spines. These fins are displaced backward, and the lower lobe of the caudal fin is not much produced. Their teeth are many-pointed. The egg cases are elongate and quadrangular, with their corners produced into long curling filaments. This family dates from the Jurassic period. The common Smooth Dogfish

(*Mustelus*) does not belong to this family, but is related to the Requiem Shark group (see page 23).

The Sand Sharks (Odontaspidae, Carchariidae): These are perhaps the most central or generalized of the higher Sharks. The body is perfectly normal and none of the fins are reduced or displaced. The teeth have needle-sharp points with small accessory cusps on either side of the base. The gill slits are of ample size and lie entirely in front of the pectoral fin. The checkerlike centra of the backbone are of the asterospondylic, or star, type, with four uncalcified streaks radiating outward from the center. The family of the Sand Sharks dates from the Cretaceous. A deep-sea member of it, *Scapanorhynchus*, has an elongate, depressed snout.

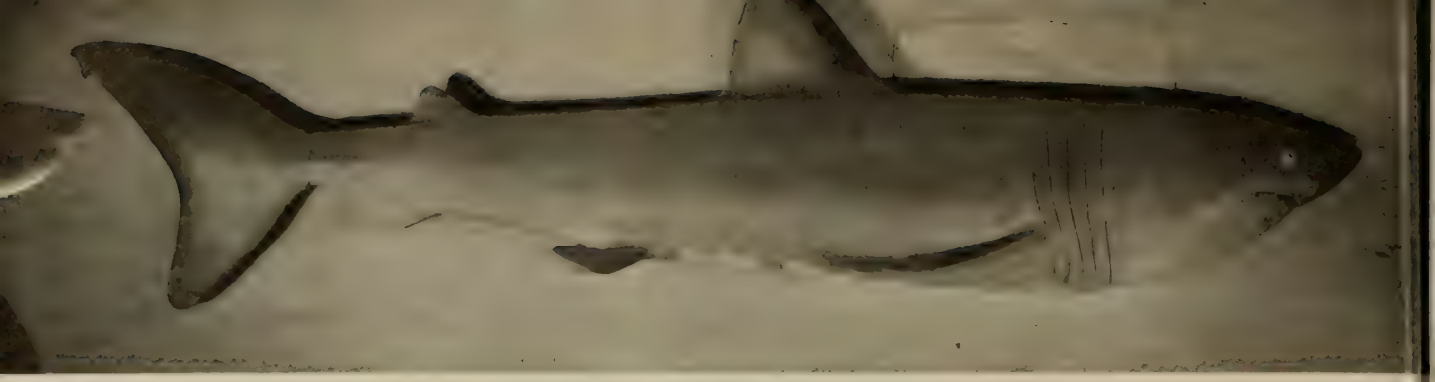
The Nurse Sharks (Orectolobidae): The Nurse Sharks are related to the Sand Sharks but are specialized for a more sluggish life. The head is typically broad and more or less depressed. The teeth are small, closely packed and flattened. The dorsal fins are more or less displaced backward. There are one or more flaps or projections of skin around the mouth. The eggs of the Nurse Shark are about as large as goose eggs, with a delicate, horny shell. It is believed that these eggs are retained in the body during the entire incubation period and that free young are released as in the Requiem or Carcharinid Sharks. In this respect the Nurse Sharks are intermediate between the true Dogfishes (Scylliidae) which are oviparous (egg-laying), and the Requiem Sharks which are viviparous (producing living young). Fossil representatives of the Nurse Shark family date from the Eocene period, between about 35 and 60 million years ago.

The Whale Shark *(Rhineodon typus):* Recent investigations indicate that the Whale Shark represents a peculiar family, possibly related to both the Nurse and the Mackerel Sharks. The Whale Shark is the largest living fish. The American Museum specimen is the mounted skin of a young Whale Shark, but the adult has been measured up to 45 feet and is estimated to reach

The world's largest fish is the Whale Shark *(Rhineodon typus)*, represented here by a young specimen harpooned by local fishermen off Cabo Blanco, Peru

Photograph by R. Norris; courtesy International Game Fish Association





A 14-foot specimen of Basking Shark (*Cetorhinus*) on exhibit in the American Museum

60 feet. The first one of these Sharks recorded by scientists was taken in Table Bay, South Africa, in 1828, since which time they have been found to frequent all warm seas. The fish is easily recognizable because of its huge size and the black and white checkerboard markings of its body.

This Shark resembles a whale in its manner of feeding as well as size. The teeth, about 3000 in each jaw and only ⅛ inch long, are set in many rows, but are useless for biting. Despite its huge size, the Whale Shark is harmless. Its food consists of small organisms filtered out of the water by its gill rakers. It has no known enemies and puts up no fight when captured by man.

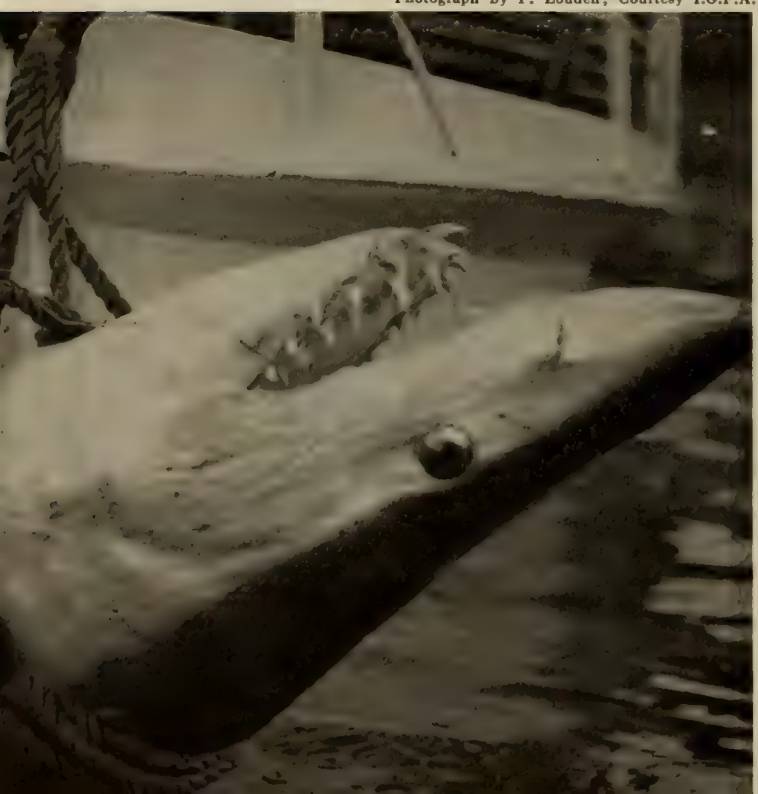


Thresher Shark (*Alopias vulpes*), which uses its enormous tail in rounding up schools of fish

A.M.N.H. photographs

A 1000-pound Mako, the world record rod and reel catch, taken off Mayor Island, New Zealand, March 14, 1943, by B. D. H. Ross

Photograph by F. Louden; Courtesy I.G.F.A.



THE BASKING SHARK (*Cetorhinus maximus*): This Shark is rather like the Whale Shark in its manner of life but is not related to it. Some ichthyologists put it in a separate family, the Cetorhinidae, although it most probably belongs with the Mackerel Sharks. It is another giant fish with very small teeth and sievelike gill rakers which strain its food from the water.

THE MACKEREL SHARKS (Isuridae): This group, which includes the Porbeagle Shark, the Mako, and the White or Man-Eater Shark, represents a swift-swimming adaptation from some ancient relative of the Sand Sharks. The upper lobe of the tail fin is turned sharply upward; its lower lobe is

produced downward so that the tail as a whole is more or less lunate, or crescent-shaped. The tail base is supported by lateral keels. The second dorsal and anal fins are much reduced.

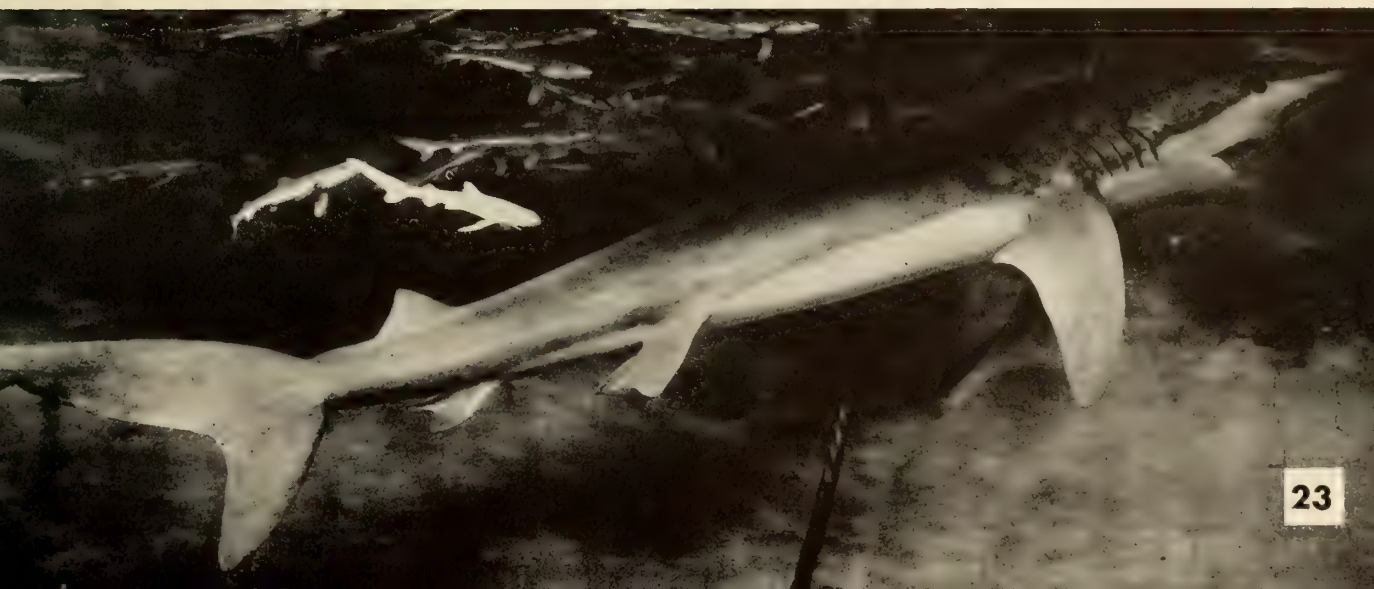
In this family the teeth range from the simple, sharply triangular teeth of the Mako to the broad, serrate-edged triangles of the White Shark and the far larger, heavier teeth of the gigantic extinct *Carcharodon* (see page 85). The gill slits are very large and are wholly in front of the pectoral fins.



THE THRESHER SHARK (Alopiidae): This is a heavy-bodied derivative of the Mackerel Shark group, from which it has inherited its very small second dorsal and anal fins. The enormous tail is used for rounding up the schools of fish upon which it feeds.

THE REQUIEM SHARKS (Carcharhinidae): These are the most numerous and dominant group of the present day. They arose later than most of the other families and their fossil teeth date back at most to the Eocene epoch. They have advanced beyond the lower Sharks (such as the true Dogfishes) by retaining the eggs within the egg tube until the young are well developed; the young are, therefore, born alive. The Requiem Sharks may be distinguished from the Sand Sharks (*Carcharias*) by the fact that the last one or two of the rather small gill slits lie above the base of the pectoral fin. The base of the tail is notched above and below, and the upper tail lobe is turned partly upward while the lower lobe is more or less produced. The Blue Shark (*Prionace*

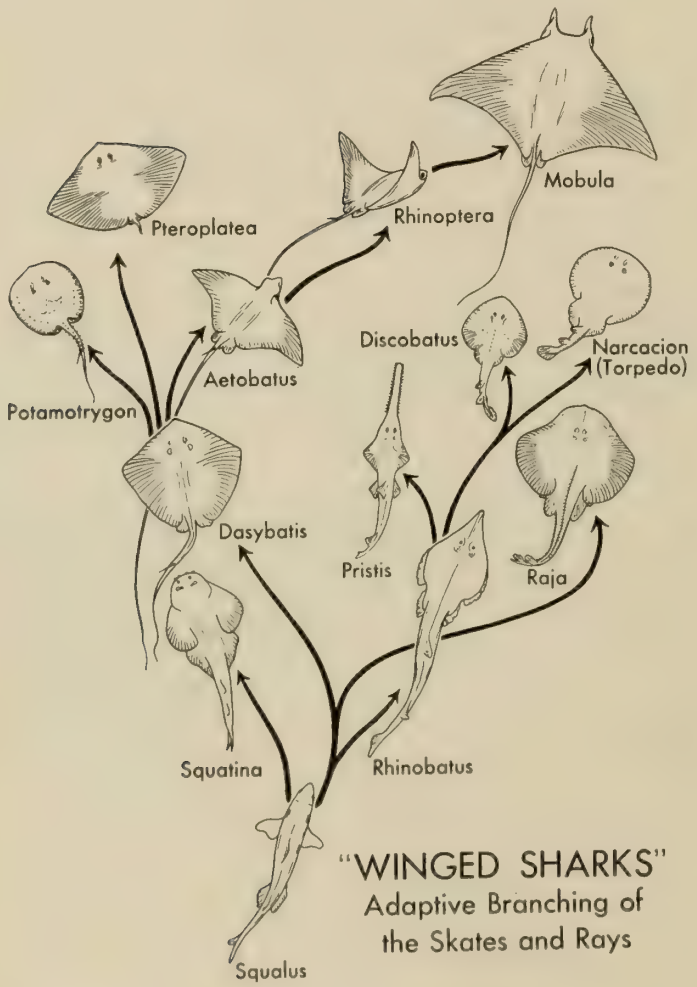
A Blue Shark and its newly born young. They are swimming about in the Sargasso Sea, under a ship, looking for food. (From an exhibit in the American Museum)



glauca) is a long, slender fish (see illustration). The Tiger Shark may be recognized by the recurved blades of its teeth. In the New York Ground Shark (*Carcharhinus milberti*) the body is heavy and the snout massive. The Smooth Dogfish (*Mustelus*) somewhat resembles the true Dogfishes (Scylliidae), but differs from them in the more normal position of the first dorsal fin which is not displaced backward. The teeth are flattened, and the fish feeds on crabs, squid, and other marine creatures.

The strange-looking Hammerhead Shark (*Sphyrna zygaena*) appears to have evolved from some more normal member of the Requiem Shark group in which the snout was very broad. The Bonnet Shark (*Sphyrna tiburo*) shows an intermediate stage in the widening of the head. The Hammerhead is a swift swimmer and can make sharp turns with great agility, apparently using the flattened head as a rudder.

Profitable commercial fisheries for Sharks are conducted in various parts of the world. Shark skin, which is covered not by scales but by hard small denticles, is used both as a polishing medium for wood and ivory, and as ornamental leather. The liver has a high vitamin content.



Skates and Rays

"WINGED SHARKS"

The Skates and Rays of the present may be regarded as transformed Sharks, in which the body has become greatly flattened and the pectoral fins enlarged and widened into "wings," which have finally become the principal organs of locomotion. The tail, in extreme cases, is reduced to a long, trailing rudder. The gill slits have been displaced onto the lower side and the water for the gills is pumped in and out through the large spiracles, or breathing holes, behind the eyes.

Several still existing forms show some of the stages by which this transformation has been brought about. The Monkfish (*Squatina squatina*) is, in fact, more or less intermediate between the Spiny Dogfishes and the Rays. Its pectoral fins are enlarged, but are still separated from the head by the gill slits, which remain lateral in position. The skull and jaws also are of the primitive sharklike type.

In the Guitarfishes (*Rhinobatus*) the front part of the enlarged pectoral fins is fastened

←Adaptive branching from primitives to "winged sharks" (Skates and Rays)

From W. K. Gregory

to the side of the head, and the gill slits are on the lower surface.

The true Sawfishes (Pristidae) are essentially like *Rhinobatus* in form. The greatly prolonged snout has acquired a row of "teeth" on either side. These, like the teeth in the mouth of Sharks, have been evolved out of denticles on the surface of the skin.

The Electric Rays, or Torpedoes, are capable of giving a powerful electric shock. The organs involved are believed to be specialized derivatives of the pectoral fin muscles and their nerves. They are the subject of investigation at the present time.

In certain Eagle Rays, the front ends of the pectoral fins begin to project beyond the mouth, and in the Manta or Devilfish, these give rise to movable flaps or "horns" which appear to assist the fish in scooping into its broad mouth the small floating creatures upon which it feeds.

The Sting Ray has a whip tail, bearing at its base a strong, saw-edged spine which can inflict a severe and irritating wound. In the Sting Rays and Eagle Rays the teeth are combined into great curved crushing plates with which the fish crushes the shells of oysters and clams.

The Skates lay eggs enclosed in tough, horny coverings, the four corners of which are prolonged into filaments. These egg cases are frequently washed up on northern beaches. In the Sting Rays and Eagle Rays the young are developed in the egg duct and the embryos draw their nourishment from the mother by means of filaments extending from their gill openings.



From a painting by A. Operti

Russell J. Coles harpooning a Devilfish (*Manta*)

Silver Sharks

CHIMAEROIDS

The existing Chimaeroids, or Silver Sharks, nearly all deep-water forms, are the descendants of certain specialized Sharks

A Silver Shark (*Chimaera monstrosa*)

A.M.N.H. photograph



of the Jurassic and Devonian periods. (See Fossil Fishes, page 86.) The living *Rhinochimaera,* with its long rostrum and tapering tail, strongly recalls this ancient stock, while *Harriotta,* a black fish from the great depths of the Atlantic and Pacific, looks like a caricature of *Rhinochimaera.* These fishes progress chiefly by means of their winglike pectoral fins. Their teeth and powerful jaws are adapted for biting and crushing. In external appearance, as well as in their cartilaginous skeleton and general anatomy, they are clearly allied with the Sharks, although in certain other features they parallel the higher fishes. Their mode of development is sharklike. Their eggs are enclosed in tough, horny egg cases, which probably lie on the sea bottom. When the young are ready to escape, the egg case opens along hingelike folds.[1]

Lungfishes

DIPNOANS

All fishes breathe oxygen dissolved in the water that passes over their gills, but there are a few which also have true lungs by means of which they can breathe even when the water in which they live dries up. These are the famous Lungfishes of Australia, Africa, and South America.

These interesting relics of long past ages (see pages 26 and 27) also have four limbs which are equivalent to the fore and hind limbs of land-living animals. The Lungfishes are distantly related to the ancestors of the swamp- and land-living amphibians.

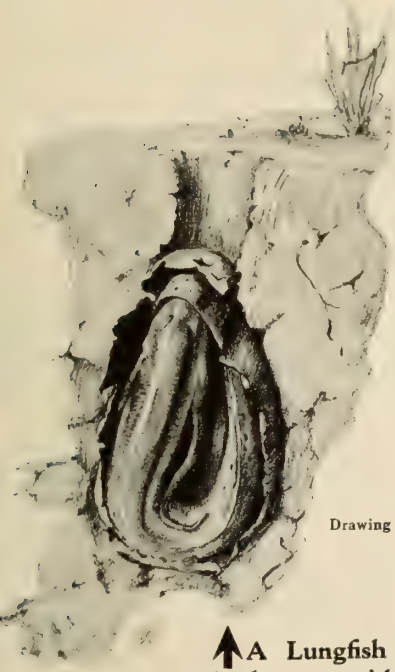
The Australian Lungfish, *Epiceratodus,* is found today only in the Burnett, Dawson, and Mary Rivers, in Queensland, Australia, where it is well known as the Barramunda and valued as food. Many millions of years ago its ancestors left their peculiar fan-shaped dental plates and other traces in the swamps of the Devonian and subsequent ages in many parts of the world, from Pennsylvania to India and from Great Britain to Australia. The Australian Lungfish lives in stagnant pools or waterholes and rises at irregular intervals to the surface, protruding its snout in order to empty its lungs and take in fresh air. The development of this fish from egg to adult is reproduced on page 11.

The African Lungfish, *Protopterus,* and the South American Lungfish, *Lepidosiren,* resemble each other in general appearance and in habit. Both live in swampy regions which dry up partially or entirely during some months of the year. At the approach of these dry seasons, the fish burrows down into the mud where it aestivates until the land is sufficiently covered with water for it to emerge again. In aestivating condi-

[1] These fishes and their development have been described in detail by Bashford Dean, in his "Chimaeroid Fishes and their Development." *Publications of the Carnegie Institution of Washington,* 1906, no. 32, 195 pp., 144 figs., 1 pl.

The Australian Lungfish (*Epiceratodus forsteri*) which lives in stagnant pools and rises at intervals to take fresh air into its lungs





Drawing by D. Blakely

A Lungfish aestivating in its burrow, with its tail curled over its nose. A small air hole has been left in the dried and caked mud at the top of the burrow so that it can breathe



A lump of clay containing an African Lungfish (*Protopterus*), which has been hacked out of the dry swamp in Africa and shipped to New York

A.M.N.H. photographs

tion, these fish have been frequently shipped overseas encased in dried mud, from which on arrival they are carefully chiseled out and put in tanks where they live and thrive. During aestivation they live on stored fat and are able to breathe through small airholes left in the mud at the top of the burrow.

In the laboratory in New York, the hard clay is carefully chiseled from the encased Lungfish

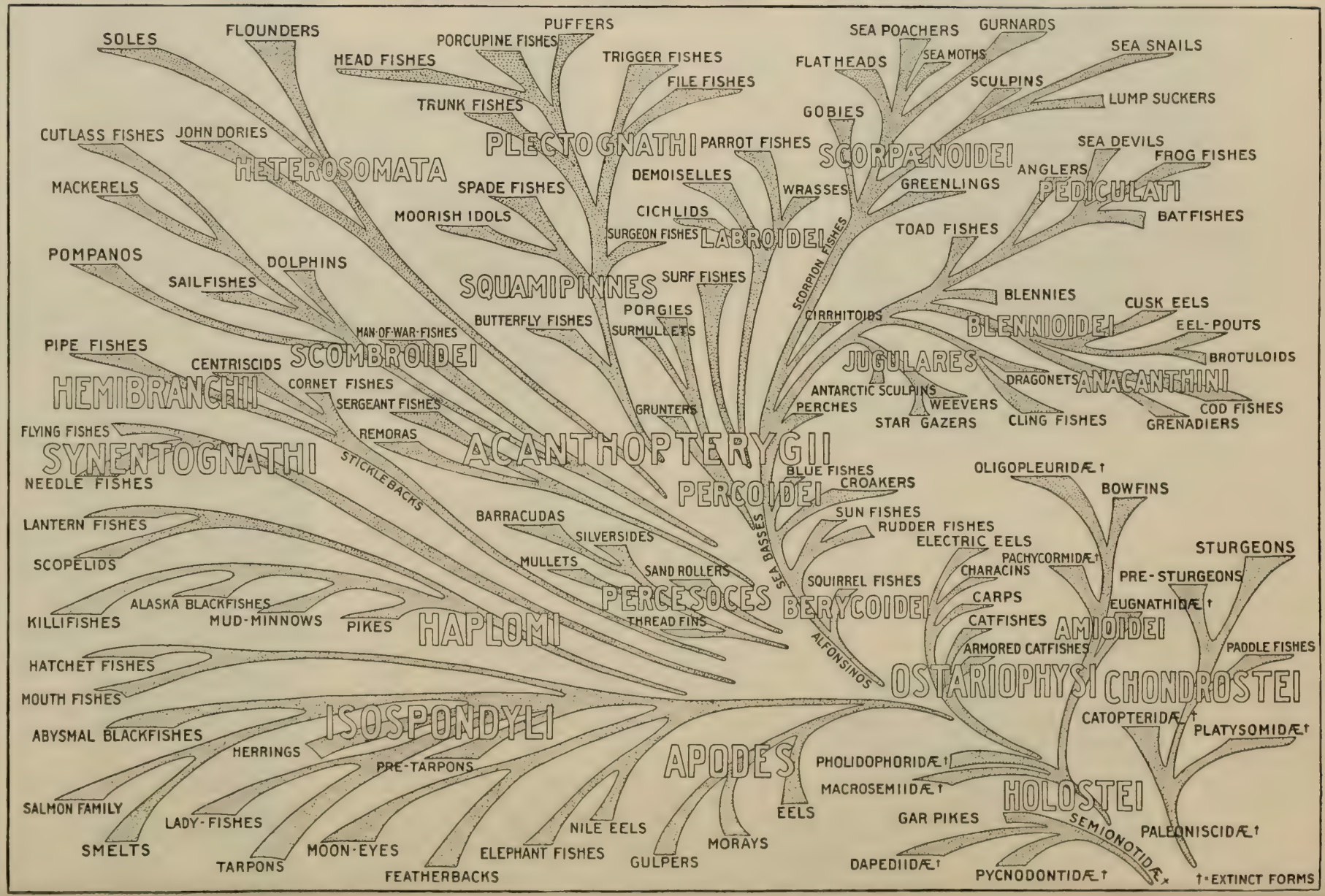


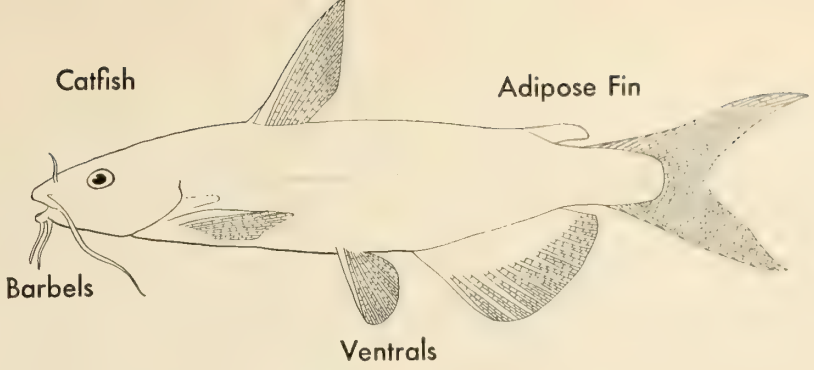
The living Lungfish, now released from its burrow, swims around in an aquarium tank



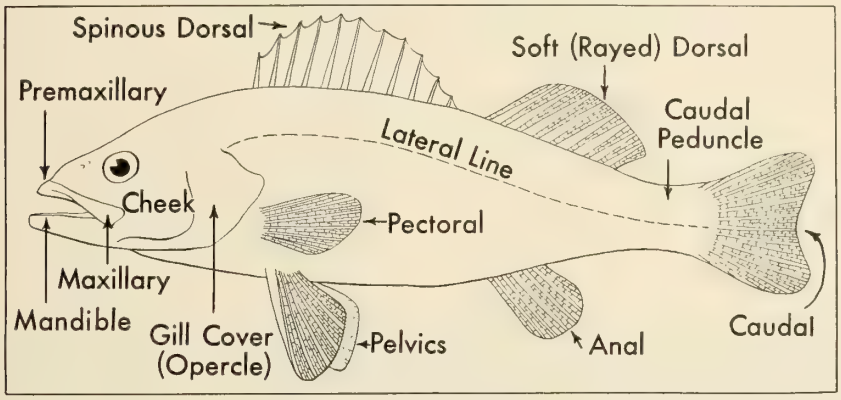
After W. K. Gregory

FAMILY TREE OF FISHES





The external diagnostic features of two kinds of Teleost fishes: Catfish and Bass. The ventral fins are also called "pelvics"



Drawings by J. Roemhild

The Higher Fishes

(Lobe-fins, Ganoids, Teleosts)

Lobe-fins

CROSSOPTERYGIANS

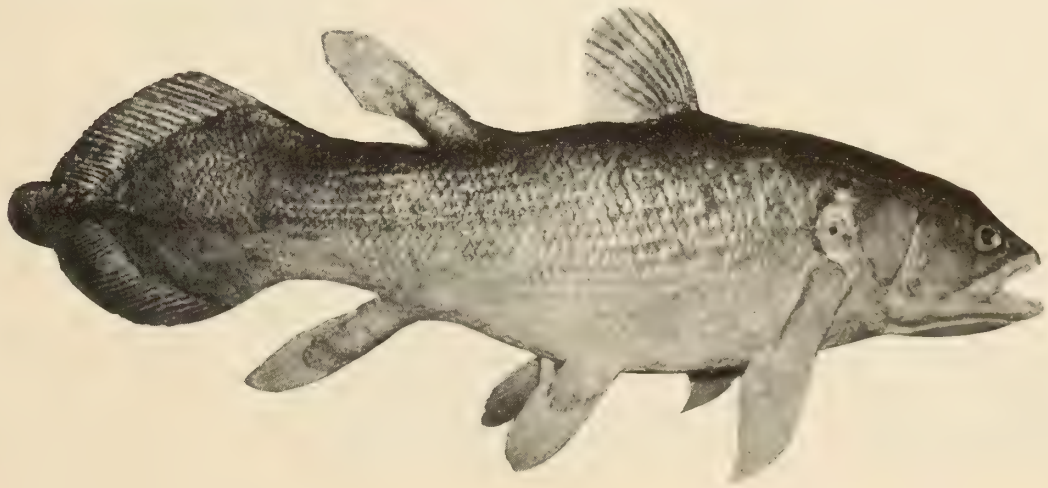
This group of extinct fishes is represented today by a single known species, *Latimeria chalumnae*, of which the only specimen so far captured was taken by fishermen in December, 1938, off East London, South Africa.

Its pectoral and pelvic fins are provided with a prominent muscular basal lobe, whence the name Lobe-fins.

The remote ancestors of *Latimeria* were related to the ancestors of the earliest four-footed animals, and there is evidence that their muscular paddles were transformed into the paired limbs.

A famous discovery: The modern Coelacanth (*Latimeria chalumnae*), netted in 1938. This antiquated fish from the Age of the Dinosaurs represents a group quite distinct from the "ordinary" bony fishes and sharks. It is the only living Crossopterygian. It fought viciously when brought up off East London, South Africa. Length, 5 feet; weight, 127 pounds

Courtesy East London Museum; world copyright strictly reserved



"Living Fossils"

THE GANOIDS

Some three hundred million years ago, the remote ancestors of these living fossils were the Old Ganoid fishes of the Devonian period. These were, in general, sharklike forms, but their bodies were covered with an armor of shiny "ganoid" scales (see Fossil Fishes, page 87). In 1833, Louis Agassiz classified them according to the character of their scales. His Ganoid group included all those in which the scales were covered externally with a thick, shiny, enamel layer, whence the name Ganoid, meaning "glistening."

The ancestral Ganoid fish (*Palaeoniscus*) had large jaws and piercing teeth, and the skeleton was partly cartilaginous.

Each living survivor of this ancient world retains some of the features of its ancestors, but each has also acquired certain specializations of its own.

The Paddlefish of the lower Mississippi River retains the ancient body form but has lost most of its scales and has acquired a spoonbill snout.

The Sturgeons also retain the sharklike form, but their mouth is sucking in type and the body is covered with bony plates. They are well known commercially because

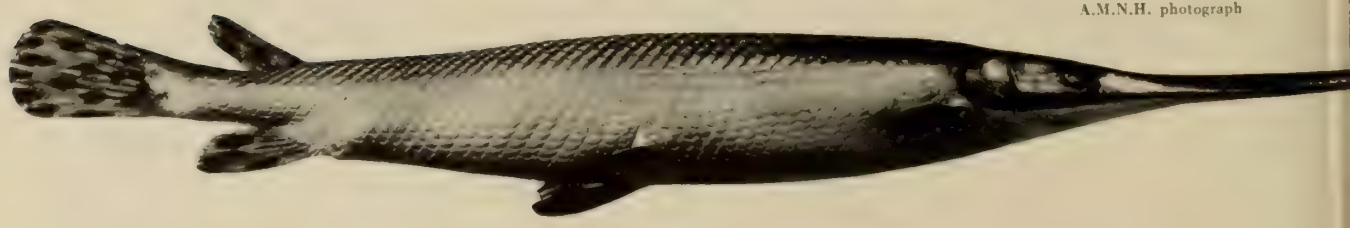


A.M.N.H. photograph

↑The Shovel-nosed Sturgeon: an exhibit in the American Museum

↓The Garpike (*Lepidosteus*) alone has inherited the complete ganoid armor of rhombic, enameled scales; its skeleton is completely bony

A.M.N.H. photograph



of the use of their roe as caviar, and their airbladder as isinglass.

The Garpike alone has inherited the complete ganoid armor of rhombic, enameled scales, but its skeleton is completely bony.

The Bowfin (*Amia*) which is a descendant of the later, or New Ganoid, stock, is the most advanced of the series and has almost attained the rank of the Teleosts or higher fishes.

The Bichir (*Polypterus*) of tropical African rivers is another surviving Ganoid. Its cylindrical body is covered with ganoid scales and the head with a bony mask. The tail has become fan-shaped and is strengthened by rays consisting of vertical rows of scales joined end to end. The dorsal fin is divided into many finlets (*Polypterus* means "many fins").

In a related fish, *Calamoichthys*, from West Africa, the body is very long, almost like that of an Eel. In both genera, the paired fins are paddles, with a stout muscular base and strong radiating dermal rays. Partly on this account, *Polypterus* was long classified as a survivor of the fossil Crossopterygians or Lobe-fins (see page 86), but good authorities now regard it as a modern descendant of the basal Ganoid stock.



A.M.N.H. photograph

The Bowfin (*Amia*) and its nest. The male fish guards the eggs and is said to protect the young (From an American Museum exhibit)

The skin of a *Polypterus*: One of the survivors of the ancient Ganoids



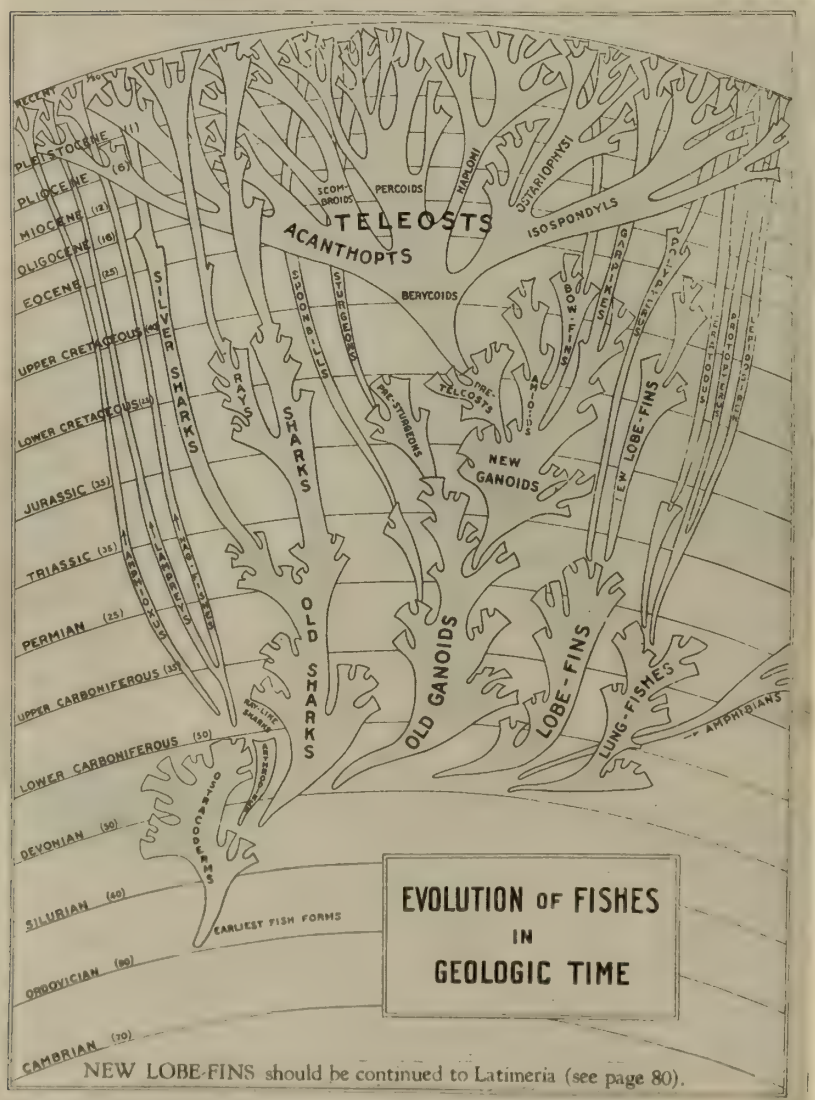
A.M.N.H. photograph

The Teleosts

During the Cretaceous period (roughly 60 to 120 million years ago), when the giant dinosaurs ruled the land, the mail-clad Ganoid fishes were largely crowded out by their more highly evolved descendants, the Teleosts, which at present constitute about 90 per cent of the fish fauna of the world. The name Teleost, meaning "completely bony," refers to the fact that the notochord, or primitive axial rod, of the larval stages of development is replaced in the adult fishes of this division by complete, bony, vertebral bodies or centra.

A simplified "family tree" showing the geological history of the fishes. The estimated duration of each geologic period is given in millions of years

From a wall chart in the American Museum



NEW LOBE-FINS should be continued to Latimeria (see page 80).

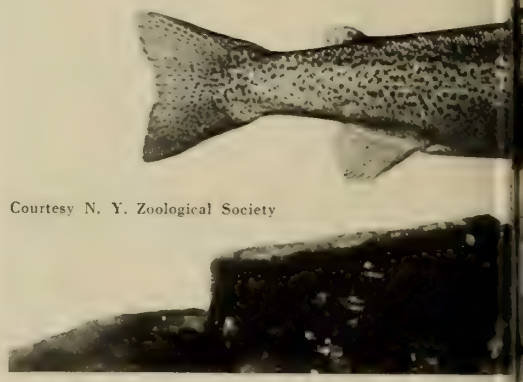
Fig. 2.—A "family tree" showing the genealogical history of the fishes

ORDER ISOSPONDYLI

(Tarpons, Herrings, Trouts, etc.)

This order, a main subdivision of the Teleost series, is a rather loose assemblage of fishes higher in rank than the Ganoids but lower than the spiny-finned fishes (Acanthopterygii). It includes such veterans as the Bonefish (*Albula*), the Tarpons, and the Herrings—all survivors from the dawn of Teleost history in the Cretaceous period (60 to 120 million years ago). It also embraces the more modernized Trouts, Salmons, etc., which are the younger scions of an ancient branch and date only from the Miocene epoch (approximately 7 to 20 million years ago). Between these two divisions come the Osteoglossids, dating from

Rainbow Trout



Courtesy N. Y. Zoological Society

***Osteoglossum*, a small species related to the giant Arapaima of South America**

Courtesy N. Y. Zoological Society



the Eocene (between 35 and 60 million years ago).

Beneath a great diversity of outward form, the Isospondyli are essentially conservative fishes, retaining the soft, or branched, fin rays of the Ganoids, the primitive duct of the air bladder connecting it with the throat, and the abdominally inserted ventral fins. The name Isospondyli means "equal vertebrae" and refers to the fact that, in contrast to the fishes of the Carp-Catfish order, the first four vertebrae behind the skull are not strongly modified.

The order Isospondyli, while vastly outnumbered in species by the higher orders of Teleosts, includes a very wide range of body form in adaptation to different modes of locomotion, and of jaws, teeth, and snouts in adaptation to different methods of feeding.

The Herrings and Tarpons: The oldest members of this order are the Leptolepidae of the Jurassic (about 120 to 155 million years ago)—small, herring-like Teleost fossil fishes of very generalized type. Next in line come the existing Bonefishes and their Cretaceous and Eocene ancestors, while the Herrings and the Tarpons follow at no great distance. The Tarpons are related to the Herrings through the fossil *Thrissopater*, from the Cretaceous.

The Herrings (Clupeidae) travel along the coasts in vast shoals, feeding on the myriads of minute forms, such as copepods and diatoms, which they strain out of the water by their gill rakers.

The Elephant Fishes (Mormyridae) are a highly specialized fresh-water group, apparently allied with the Albulidae. These strange fishes of the Nile River were venerated by the ancient Egyptians, who believed that the Mormyrids had eaten a piece of the body of the god Osiris.



A Tarpon leaping

Drawing by D. Blakely



The Elephant Fish (*Mormyrus kannume*), in New York Aquarium

Courtesy N. Y. Zoological Society





A.M.N.H. photograph

Atlantic Salmon on display in the Hall of Fishes of the World

THE MOONEYES OR GOLDEYES (Hiodontidae) are herring-like fishes of the fresh waters of North America. They stand near the common center of a number of other specialized relics of long past ages, such as the Featherbacks (Notopteridae) of West Africa, India, and Sumatra, and the Osteoglossidae from eastern South America, West Africa, and the Malay-Australian region (see chart page 28).

THE DORAB (*Chirocentrus*) of the Indian Ocean is the dwarfed survivor of a Cretaceous family that includes the gigantic *Portheus* (see Fossil Fishes, page 89).

THE SALMON AND TROUT (Salmonidae) are the highest and most beautiful members of the soft-rayed group of fishes. They are limited to the northern world, except for those that have been transplanted to New Zealand and Tasmania. They delight in cool waters, and many species of trout are found in the lakes and streams that were left by action of the great glaciers of the Ice Age.

The Salmons are famous for their habit of coming up from the sea to spawn, traveling upstream sometimes hundreds of miles, jumping the rapids and penetrating as far as possible toward the purer waters of the north. At the end of this journey they release the eggs and milt that give rise to the next generation. After spawning, the Pacific Salmons die, and in Alaska the streams are choked with their dead bodies, so that sea gulls fly many miles inland to feed upon them. The young salmon, or parr, gradually make their way down to the sea. The life cycle of the Chinook Salmon is illustrated in a miniature group in the American Museum's Hall of Fishes.

The Salmons and Trouts, unlike their relatives the Herrings, are predaceous fishes with strong teeth. The family, as far as is known, dates only from the Miocene (about 7 to 20 million years ago).

DEEP-SEA RELATIVES OF THE SALMON AND TROUT: The fantastic forms and coloring of the Boa Fishes (Stomiatidae and related families) are in keeping with the world of darkness and cold in which they live and breed their sensitive young. Their large eyes serve to catch the phosphorescent glow produced by other creatures, while their own light-producing organs, marked by

spots on the sides of the body, serve to attract their prey.

The Stalk-eyed Fish: Ichthyologists had long known these minute, deep-sea fishes, whose eyes were placed at the ends of long stalks, and had called them *Stylophthalmus.* In 1934, Dr. William Beebe showed that these Stalk-eyed Fish were merely the young of a very different looking adult fish with normal eyes—*Idiacanthus.* The American Museum has an exhibit showing the stalk-eyed stage, a later stage in which the eye stalks are shortening, and, finally, the adult stage where the eyes have finally been drawn back into sockets in the skull in the normal position.

The males of *Idiacanthus fasciola* are only about 1½ inches long; the females are seven times larger. The digestive tract of the males is reduced and functionless, and they have no teeth; the females have a carnivorous digestive tract and large teeth.

Dr. Beebe collected the larval fish off Bermuda at 100 fathoms, the adults at between 500 and 1000 fathoms.

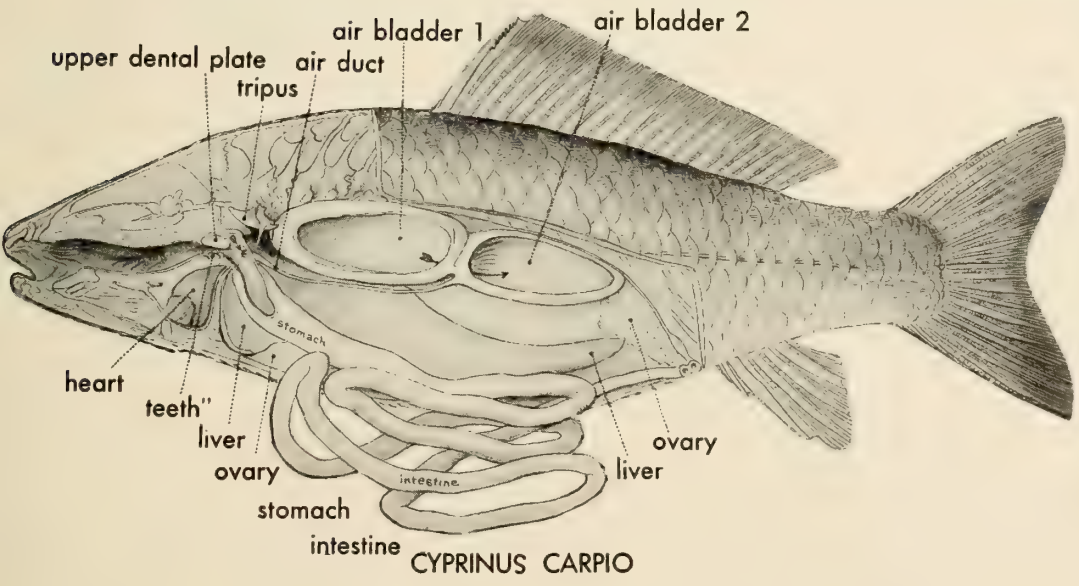
ORDER OSTARIOPHYSI
(Characins, Carps, Catfishes, etc.)

The members of this order are nearly all fresh-water fishes. Its most specialized members, the Catfishes, date from the Eocene epoch (35 to 60 million years ago), so the earlier ancestral forms must be sought perhaps in the Cretaceous. Thus the group may have been derived from some very early Teleosts, possibly the Leptolepidae of the Jurassic.

The Weberian Apparatus: The members of this group possess one of the most remarkable of all animal mechanisms—the Weberian apparatus. This consists chiefly of a linked series of small bony levers and springs which is attached at the lower end to the swim bladder and at the upper end to the back of the so-called inner ears, or organs of balance. Some authors hold that this apparatus serves to collect pulsations coming in from the water, to modify them, and to transmit them to the nerves of the internal ears. Others hold that its chief function is to transmit not sounds but sensations of varying pressure. The small bony levers and springs represent highly modified ribs and other parts of the first four vertebrae behind the skull. This apparatus is found in no other order of fishes.

Anatomy of the carp, showing "teeth" in throat and long intestine. The "tripus" transmits vibrations from the air bladder to the inner ear

Drawing by L. Nash





A.M.N.H. photograph

The Mahseer, or Giant Carp of India (*Barbus tor*)

Carps and Loaches (Suborder Eventognathi): Everyone who has watched a living Goldfish must have noticed how it can shoot out its toothless jaws and draw in bits of food, but not everyone knows that the Goldfish, like all other members of the Carp family, carries an elaborate dental apparatus in its throat. This apparatus consists of four series of teeth located on the upper and lower pharyngeal bones, which are the rear segments of the jointed gill arches. It is to this peculiar arrangement that the name Eventognathi, meaning "wholly internal jaws," refers.

Carps are mostly sluggish fish that feed on vegetable matter found on the muddy bottom. They form one of the dominant fresh-water families of Asia, Europe, and North America.

To this group belongs the Bleak, *Alburnus,* the silvery substance of whose scales is used in the manufacture of artificial pearls.

A giant member of the group, the Mahseer, *Barbus tor,* is found in India where it occupies a very high rank as a game fish.

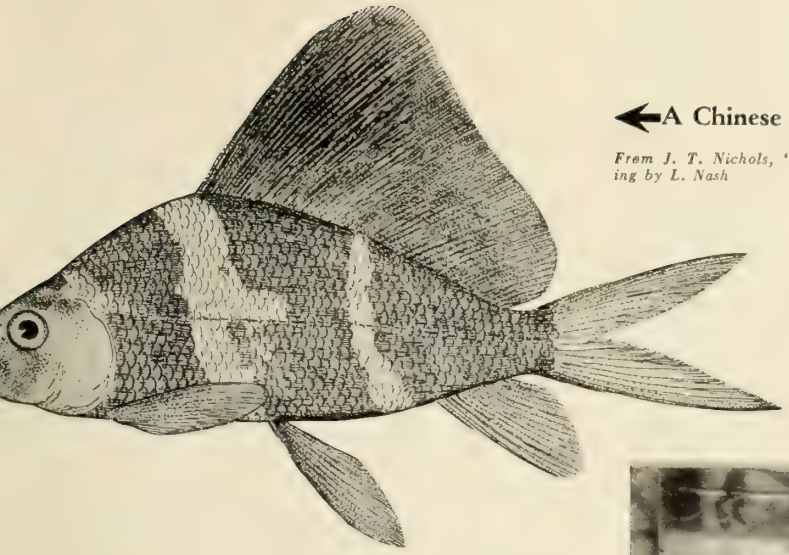
Fossil carps have not yet been found below the Miocene formations of Europe, representing an era approximately 20 million years ago.

Chinese Carps: The Carps of China are related to the Suckers and Carps of North America. But whereas in the latter country the representatives of other fresh-water families are far more numerous, in China the Carps are dominant and have given rise to a great variety of forms which in external appearance recall diverse fishes of other parts of the world.

Characins (Suborder Heterognathi, a name which implies variety in the jaws and teeth): The vicious Piranha forms the central type of this numerous and widely varied South American and African group, among which occur some of the favorite aquarium fishes. The Characins, unlike their distant relatives the Carps, are mostly carnivorous and have well-developed teeth in the jaws, but no throat teeth. They are further characterized by having an adipose fin (see diagram page 29).

The Electric Eel (*Electrophorus electricus*): The Electric Eel is not related to the true Eels, but is a highly modified Characin. It grows to a length of over 8 feet and a weight of over 100 pounds. The fish is given to lying still in shallow water for long periods, broken only by moves to the surface to gulp air. It is the most powerful electrically of the electric fishes and can give a very severe shock and continue discharging for several hours.[1] As in other electric fishes the electric organs appear

[1] A series of papers on this subject was begun in 1937 by C. W. Coates, R. T. Cox, and associates, and is still in progress. Most of these have appeared in *Zoologica* (New York Zool. Soc.).



← A Chinese Carp, *Myxocyprinus asiaticus*

From J. T. Nichols, "Chinese Fresh-Water Fishes," 1928; Drawing by L. Nash



Courtesy N. Y. Zoological Society

↑ A Piranha in a New York Aquarium tank: a vicious fish from South America



Courtesy N. Y. Zoological Society

← Jaws of a large Piranha, showing the ferocious teeth

↓ The Electric Eel (*Electrophorus electricus*) of South America, the most powerful of the electric fishes

Courtesy N. Y. Zoological Society





Courtesy of N. Y. Zoological Society

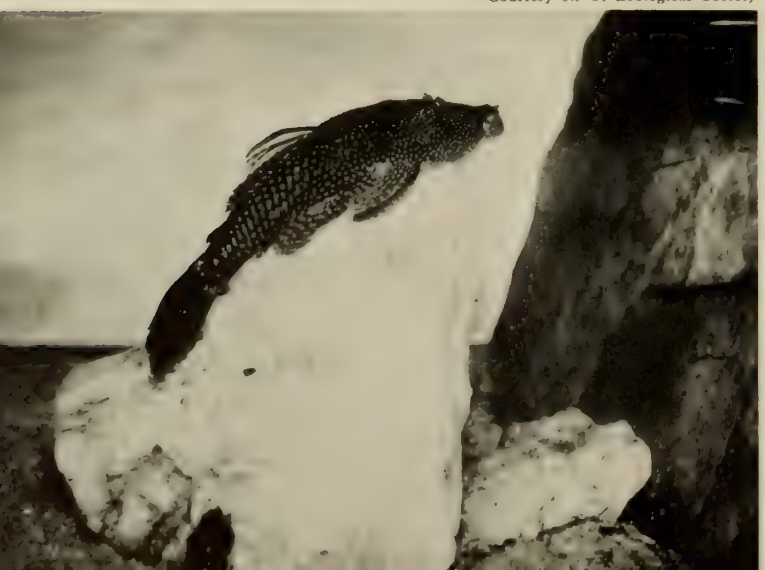
↑The Common Bullhead, typical of the abundant Catfishes of North America



Courtesy of N. Y. Zoological Society

↑One of the Armored Catfishes: *Callichthys*. The armor consists of a double row of overlapping shields on both sides of the body

Courtesy N. Y. Zoological Society



←An Armored Catfish, *Plecostomus*, in the New York Aquarium. These fishes are covered on the back, head, and sides with bony plates, sometimes armed with small, prickly spines. The under part of the body is often unprotected. *Plecostomus* spends much of its time clinging to the stones of stream beds

to have been derived from combinations of highly specialized parts of the muscular and nervous systems.

Catfishes (Suborder Nematognathi): Catfishes are the scavengers of the river bottom mud. Their scaleless, slimy bodies are covered with sensory cells that taste the food dissolved in the water. The long barbels around the mouth doubtless aid them in feeling their way about in the semi-darkness and partly compensate for their very small eyes. The teeth are small or lacking, and the mouth serves as a wide scoop. The maxillary, or rear bone of the upper jaw, is reduced to a small movable base for the main barbel, whence the name Nematognathi, or "thread-jaw." The pectoral and dorsal fins bear strong spines which are often dangerous weapons.

Catfishes have lost their scales, but some of them, especially the Armored Catfishes (Loricariidae), have acquired secondary derm-bone plates covering the body.

ORDER HAPLOMI
(Pikes, etc.)

This order is intermediate in its anatomical characters between the Isospondyli, or lower Teleosts, and the spiny-finned, or higher Teleosts. The name Haplomi ("simple shoulder") alludes to the simplified character of the shoulder girdle, which lacks the mesocoracoid arch or middle inner brace of the bony base of the pectoral fin.

This structure is present in all Ganoids and lower Teleosts, in which the pectorals are held in a more horizontal plane, but it is lost in the higher ones, in which the resting pectorals are held in a more vertical plane.

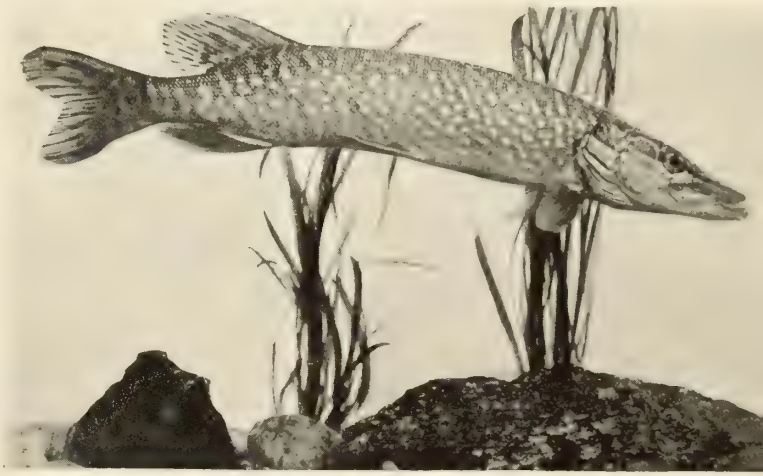
The Pikes, Pickerels, and Muskellunge lie in wait for their prey, making swift rushes to snap it up with their long, sharp-toothed jaws. They employ the same technique in taking bait and are very game fighters when hooked.



Photographs from live specimens in the tanks of the New York Aquarium

Pickerel

Pike



ORDER CYPRINODONTES
(Microcyprini)

This order includes the Killifish family, several members of which have been successfully used in mosquito destruction. They are small fishes with tiny mouths, but they retain the pikelike backwardly placed

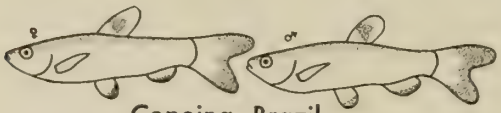
Muskellunge



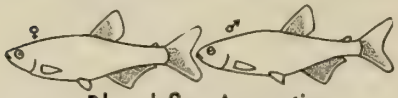
A SIMPLIFIED PICTORIAL CLASSIFICATION

ORDER OSTARIOPHYSI
Characins, Carps and Catfishes

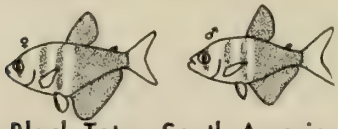
Family Characidae
Characins



Copeina, Brazil
Copeina guttata (Steindachner)

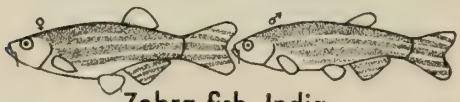


Blood fin, Argentina
Aphyocharax rubripinnis Pappenheim



Black Tetra, South America
Gymnocorymbus ternetzi (Boulenger)

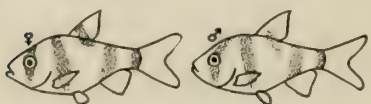
Family Cyprinidae Carps



Zebra fish, India
Brachydanio rerio (Hamilton-Buchanan)



Red Rasbora, Malay and Sumatra
Rasbora heteromorpha Dunker



Sumatra Barb, Siam and Malay Pen.
Barbus partipentazona Fowler

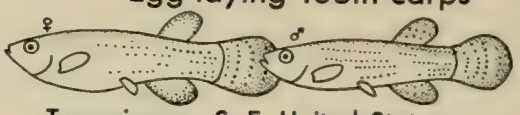
Family Callicthyidae Catfishes



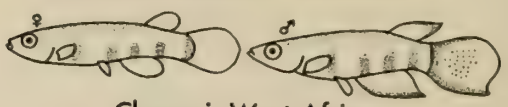
Armored catfish, Trinidad
Corydoras aeneus (Gill)

ORDER CYPRINODONTES
Killifishes, Top-minnows, etc.

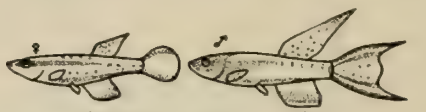
Family Cyprinodontidae
Egg-laying tooth-carps



Top-minnow, S. E. United States
Fundulus chrysotus Holbrook

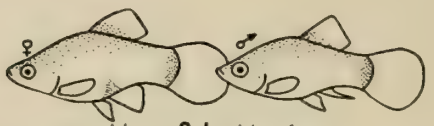


Chaperi, West Africa
Epiplatys chaperi (Sauvage)

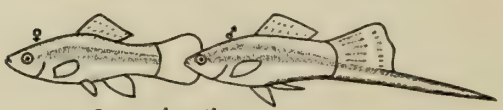


Bivittatum, West Africa
Aphyosemion bivittatum (Loennberg)

Family Poecillidae Live-bearers



Moonfish, Mexico
Platypoecilus maculatus Guenther



Sword tail, Mexico
Xiphophorus helleri Heckel



Sail-fin Mollie, Southern U. S. and Mexico
Mollienisia latipinna Le Sueur



Guppy, Northern South America
Lebistes reticulatus (Peters)



Belonesox, Honduras
Belonesox belizanus Kner

OF THE MORE COMMON AQUARIUM FISHES

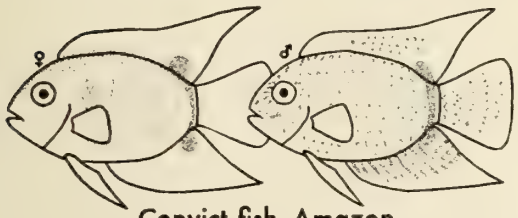
ORDER PERCOMORPHI

Cichlids, Nandids, etc.

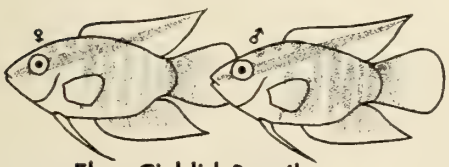
Family Cichlidae
Cichlids



Mouthbreeder, Egypt
Haplochromis multicolor (Hilgendorf)



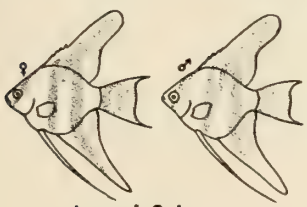
Convict fish, Amazon
Cichlasoma severum (Heckel)



Flag Cichlid, Brazil
Cichlasoma festivum (Heckel)



Jack Dempsey, South America
Cichlasoma biocellatum Regan



Angel fish, Brazil
Pterophyllum scalare
Cuvier and Valenciennes

Family Ambassidae Ambassids

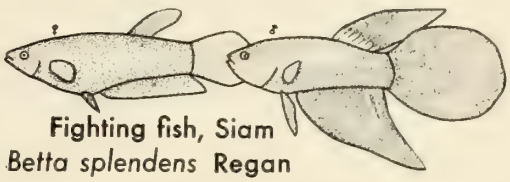


Glassfish, India
Ambassis lala (Hamilton-Buchanan)

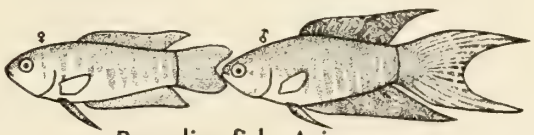
ORDER LABYRINTHICI

Anabantids, etc.

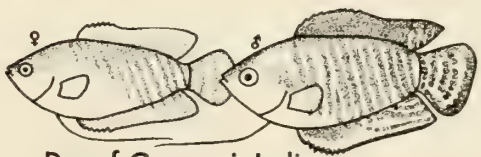
Family Anabantidae
Anabantids



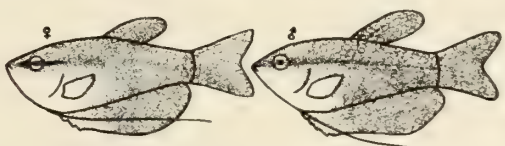
Fighting fish, Siam
Betta splendens Regan



Paradise fish, Asia
Macropodus opercularis (Linnaeus)



Dwarf Gourami, India
Colisa lalia (Hamilton-Buchanan)



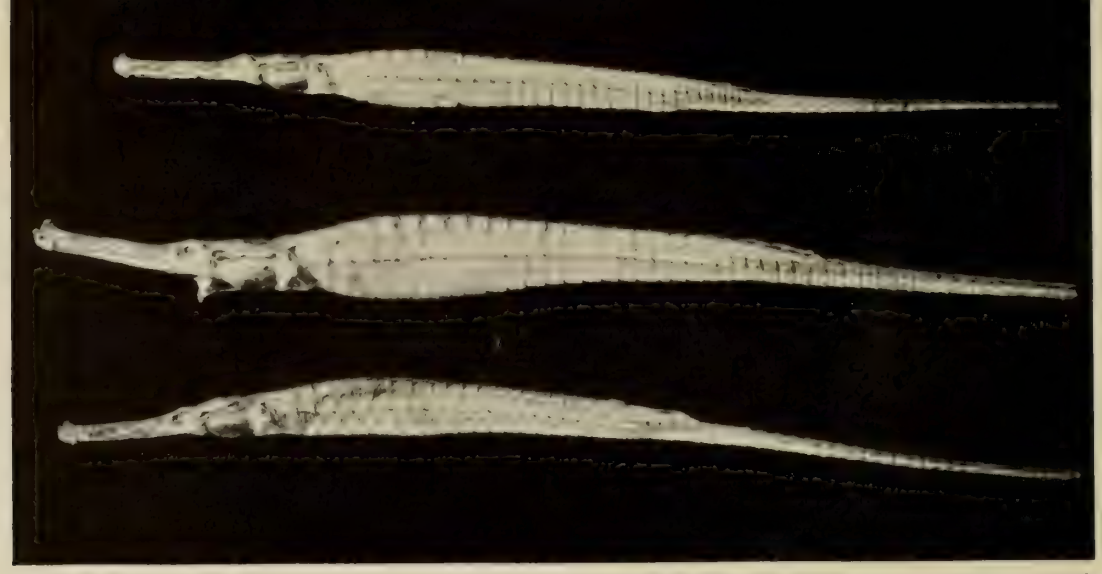
Pearl Gourami, Malay Pen., Siam
Trichogaster leeri (Bleeker)



Kissing, Gourami, Malay region
Helostoma temmincki Cuvier and Valenciennes

D. Marcy

Chart by D. Marcy



A.M.N.H. photograph

↑Pipefishes. These are relatives of the Sea Horse but are less specialized and more fishlike in form and movements

dorsal and anal fins, and broad tails that enable them to make swift turns.

Owners of "tropicals" do not need to be told that their beloved Guppies are live-bearers! The same is true of Mollies, Swordtails, Platies, and a number of others. The young are active at birth and able to forage for themselves. These "Live-bearing Toothed Carps" are nearly all members of a single family, the Poeciliidae. The majority of the "Egg-laying Tooth Carps," including *Rivulus, Fundulus, Panchax,* etc., are members of the family Cyprinodontidae. In these fishes the ripe eggs are extruded and either stick to aquatic plants, drop to the bottom, or hang pendant from the female fish.

In the typical live-bearers (Poeciliidae), the anal fin of the male is modified into a groove (gonopodium) through which the fish deposits a capsule of sperm at the genital pore of the female. This internal fertilization permits the fertilized eggs to develop inside the body of the female, and the young are born alive. In the related Cyprinodontidae, however, the males having no such structure, fertilize the eggs at the time they are extruded from the female fish, and the embryonic development takes place in the water.

The Tooth Carps are not related to the true Carps (see page 36).

ORDER INIOMI
(Lizard Fishes)

These large-mouthed, needle-toothed fishes are in certain respects intermediate between the salmonlike forms of the soft-rayed order and the Pikes and their allies of the order Haplomi. Many of the deep-sea members of the family (Myctophids) have a series of light-producing spots on their body and head. These light organs have been developed independently in different groups of deep-sea fish. They appear to be essentially highly specialized lateral line scales, in which the surface layer has become transparent like a lens, while the chromatophores or pigment organs have produced both the silvery and black pigments, and the light giving substance, luciferin.

In some of the Lizard Fishes living at great depths, e.g. *Bathypterois,* the eyes are reduced or absent, and the rays of the pectoral fins are prolonged into delicate feelers.

The family is an ancient one, dating from the Upper Cretaceous period.

ORDER THORACOSTRACI

(Sticklebacks, Tubefish, Sea Horses, etc.)

This order includes a number of very peculiarly formed fishes, some of which swim in a vertical position.

The Sticklebacks (Gasterosteidae): These fishes are so called because of the three or more isolated spines which represent the spinous dorsal fin. The smaller two- and three-spined Sticklebacks can be transferred from fresh to salt water or vice versa without harm, but the larger, fifteen-spined *Spinachia* is entirely marine.

The male Stickleback builds a nest of weeds, held together by a thready secretion from the kidneys. He then guards the eggs deposited by the female. These fishes are short lived and probably only breed once.

Fishes with Tubiform Snouts (Aulorhynchidae, Aulostomatidae, Amphisilidae, Centriscidae): The Aulorhynchidae are closely related to the Sticklebacks, but their elongate snouts approach those of the Trumpet Fishes or Aulostomatidae of the West Indies, Polynesia, and Asia. A species of *Aulostomus* is found in the Eocene of Italy.

The Snipefish, *Centriscus,* is heavier bodied than most of its relatives and bears a long spike on its dorsal fin. Its minute, toothless mouth is at the end of a long snout.

The Shrimpfish, *Amphisile,* has a long thin body enclosed in thin bony armor. This armor extends at the tail end of the body in a long spine which runs above and beyond the tail fin. *Amphisile,* like the Sea Horse, swims in a vertical position.

The Syngnathidae, which include the Pipefishes and the Sea Horses, are more or less elongate and are protected by a jointed armor of horny plates. The snout is prolonged and tubiform, and the tail is sometimes prehensile. In most species, the male takes charge of the eggs in a pouch under the tail or on the abdomen. By rapid vibration of their delicate pectoral and dorsal fins, these fishes move gently through the water, catching at floating weeds with their prehensile tails. The Australian Sea Horse, *Phyllopteryx,* is remarkable for the cutaneous appendages that float out from its body like seaweed.

The Northern Sea Horse, *Hippocampus,* is common on our coast in summer, from Charleston, South Carolina to Cape Cod, Massachusetts. There are various Sea Horses scattered around the marine waters of the world. They range in color from red to bright yellow. Our northern species is brown. They swim in a vertical position.

Australian Sea Horse

A.M.N.H. photograph





The Common Eel (*Anguilla bostoniensis*)

The Spotted Moray in a tank in the New York Aquarium. The Moray thrives in captivity and can be kept for years in aquarium tanks

Courtesy N. Y. Zoological Society



ORDER APODES
(The Eels)

The Eels have cast aside all superfluous fins, drawn out the smooth cylindrical body into a compressed tapering end, and multiplied the muscle segments until they can undulate as easily as a streamer waves in the wind (see page 13). In some families of Eels, the scales are entirely lacking, but in the most common Eel, *Anguilla,* they are present, although vestigial and imbedded.

The true Eels of Europe and America all go to the deep sea to spawn. There is an area south of Bermuda where all such Eels have been thought to spawn, and certainly they seek either this or similar ocean conditions. The eggs hatch flat, translucent larvae known as Leptocephali. These are so unlike the adult fish that they have sometimes been classified as distinct fishes. Those to the westward of the breeding area gradually drift, as they grow, toward America; those to the eastward, toward Europe. When they approach shore, they are several inches long. On entering coastal waters, they shrink and take on the appearance of Eels, although they are still more or less transparent. Some of them remain and grow in coastal salt or brackish waters, and others penetrate far inland, becoming the fresh-water Eels of the interior. A minature group in the American Museum's Hall of Fishes illustrates the life history of the Common Eel and the commercial utilization of this fish.

The Conger Eel does not enter fresh water. It moves away from the shore to spawn. Both it and the Common Eel die after spawning.

The Moray and the Conger are the largest of the Eel tribe. The Morays are typical reef fishes and have long jaws armed with sharp teeth. They differ from the Conger in their lack of pectoral fins and in the beautiful color patterns of their skin.

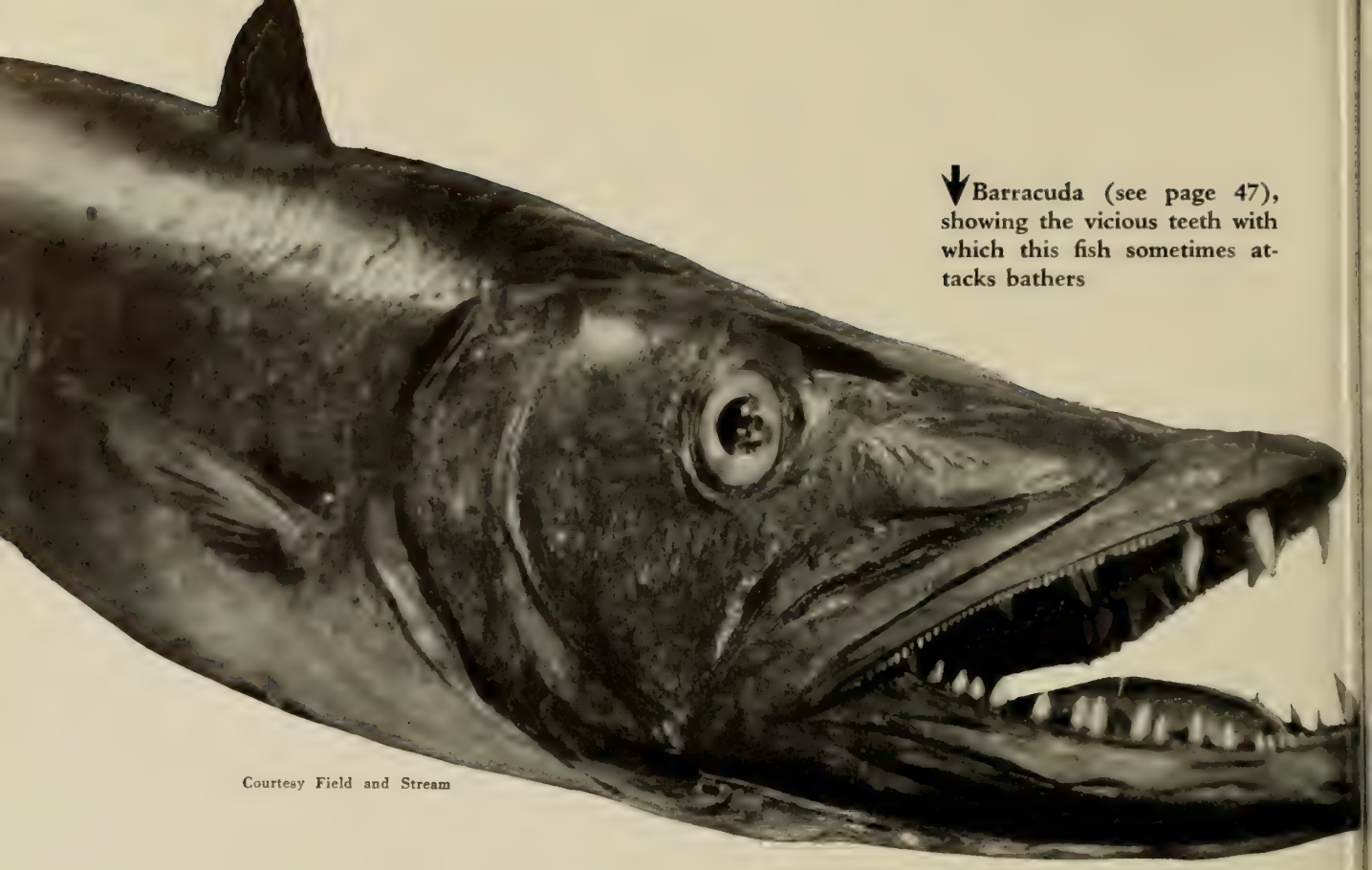
ORDER SYNENTOGNATHI
(Flying Fishes, Needlefishes, etc.)

Several unrelated groups of fishes have independently developed the ability to fly, but the Exocoetidae, or Marine Flying Fishes, excel all others in aerial powers. They are characteristic of the trade wind belts of open, tropical oceans. These, of all

Flying Fish and Airplane

Photograph by Lilo Hess





Courtesy Field and Stream

Barracuda (see page 47), showing the vicious teeth with which this fish sometimes attacks bathers

flying animals, most closely resemble the modern airplane. The proportions of the Flying Fish and the airplane are very close in spite of the difference in size.

Being an organic unit and not a rigidly articulated machine, the fish is capable of greater flexibility of movement and has some adjustments not yet possible in a plane. In both the Flying Fish and the airplane, the camber of the wings, their placement, and the presence of stabilizer fins at proper places are remarkably similar, considering the form, size, and landing requirements of each. One of the most striking differences is the complete absence of any landing gear on the fish. This is a notable economy which is possible because the fish can plunge into the water headfirst or drop without injury in a manner that would wreck a plane.

The average rise of these fishes above the water is about 5 feet, although they occasionally rise higher. The length of flight varies from 50 to 300 feet, but with the wind they have been observed to fly a quarter of a mile. Turning is accomplished by use of the body muscles and tail fin. The wings, when in flight, remain like the wings of a glider. The larger the fish, the longer the flight will be and the fewer the dippings of the tail into the water for added impetus.

About twice as many Flying Fishes fly in schools of two or more as fly alone. The predominant form in the Gulf Stream is *Parexocoetus mesogaster*.

The Flying Fish appears to be an offshoot from some early member of the spiny-finned order.

Other Flying Fishes: Three other fishes not related to the Synentognaths have powers of flight. These are:

The South American Fresh-Water Flying Fish (*Gasteropelecus*), a small fish related to the Piranha and belonging to the family Characidae (page 36). This fish can make a flight of from 5 to 10 feet.

The African Fresh-Water Flying Fish

(Pantodon): This is a small Isospondyl related to the Herring-Trout group (page 32). It has very slight powers of flight.

The Flying Gurnard (*Dactylopterus*): This is one of the mail-cheeked fishes, related to the Sea Robins and Sculpins (page 56). The Flying Gurnard is said to leap above the water and glide on its relatively large breast fins for a short journey.

ORDER PERCESOCES
(Barracuda, Mullet, etc.)

The Barracuda *(Sphyraena)* is one of the most piratical looking of all sea-going crafts; a swift, fierce fish with a formidable array of large sharp teeth. It may be easily recognized by its silver and blue body, its pikelike form, and its separate spiny dorsal fin. This separate spinous dorsal is also a character of such peaceful kinsfolk of the Barracuda as the Silversides (Atherinidae) and Mullets (Mugilidae). The latter feed on other small animals, algae, and occasionally on vegetable matter. They resemble the Flying Fishes in the high position of their breast fins, and the group as a whole may be distantly related to that assemblage.

In the Malay-Philippine region there is a family of minute fishes believed to be closely related to the Silversides and Mullets. These are the Phallostethidae. In these fishes internal fertilization is effected by enlarged and modified pelvic fins and genital ducts, which in the males have been changed into an intromittent organ.

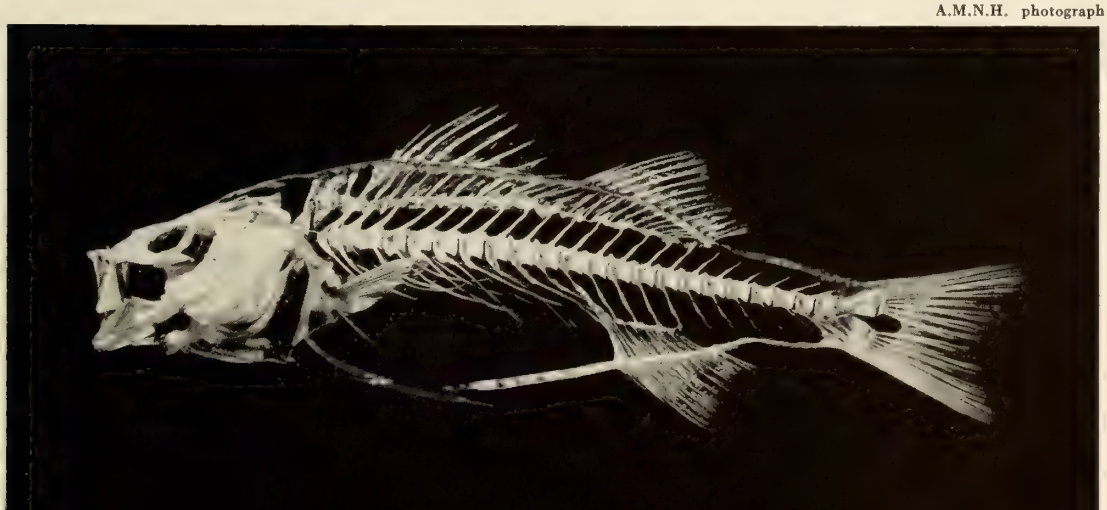
ORDER ACANTHOPTERYGII
(The Spiny-finned Fishes)

The vast majority of existing species of fish belong to the spiny-finned order, the most characteristic and unchanging features of which are illustrated in the skeleton of the Striped Bass. Usually the soft, branched rays of the dorsal and anal fins in these fishes are preceded by one or more sharp-tipped spines. There may also be such a spine preceding the rays of the pectoral and ventral fins. The typical body form of the spiny-finned fish is fairly stout, with a broad, strong tail base and bony tail—all signs of vigorous swimming ability. Another characteristic anatomical character is that the pelvis, or bony base of the ventral fins, is prolonged forward and connected to the shoulder, or pectoral, girdle where the lower two ends of the latter meet. This arrangement facilitates quick turning and stability.

These fishes usually have strong jaws and teeth, and prey upon other fish. The front upper jaw bone (premaxilla) is prolonged backward and downward so that it shuts out the second upper jaw bone in back of it (the maxilla) from immediate contact with the corner of the mouth. The maxilla is toothless and acts only as a lever for pushing forward the premaxilla.

Skeleton of Striped Bass

A.M.N.H. photograph



THE BASSES AND THEIR ALLIES (Suborder Percoidei): The true Basses (Serranidae) and their allies stand near the center of the great assemblage of spiny-finned fishes. They are mostly stout-bodied fishes, usually swift and voracious. Most of them prey upon smaller fishes, crabs, shrimps, and other crustaceans. Many are brilliantly colored and some, such as the Rockfishes, undergo pronounced color changes, sometimes having as many as four definite and very different color phases. Many factors in addition to conformation to the environment are involved in these changes.

The Snappers (Lutianidae) are carnivorous food fishes, closely allied to the true Basses, but often having a longer face from the tip of the upper jaw to the lower border of the eye. The back part of the upper jaw slips under the lower border of the enlarged front suborbital bone and is thus concealed when the mouth is closed. Above each ventral fin there is often a very much enlarged scale. These fishes are usually very brightly colored.

The Grunts (Haemulidae) are also called Roncos, from the Spanish verb *roncar* which means to grunt or snore. This refers



←**Gray Snapper (*Lutianus*)**

Photograph: N. Y. Aquarium, N. Y. Zoological Society

↓**Yellow-striped Grunt (*Haemulon*)**

Courtesy N. Y. Zoological Society



to the noise the fishes make either with the very large pharyngeal teeth or the complicated air bladder. These are also tropical fishes.

The Porgies (Sparidae) are well known in our markets through the Northern Porgy. In these fishes the pharyngeal or throat teeth become very large and pebblelike, and in one form, the Sheepshead, the front teeth of the upper and lower jaws are also strongly developed, so that with them the fish can pluck up crustaceans, which are then crushed by the teeth in the throat. The Porgies occur chiefly in warm waters and many of them are vividly colored, often with a ground color of crimson.

The Basses: The true Basses (Serranidae) include the Sea Bass, Striped Bass, the White Perch of this vicinity, the Rockfish and the Groupers of the Florida Keys and south, besides many others in various parts of the world.

Most of these have three well-developed anal fin spines, and the back part of the upper jaw is quite distinct when the mouth is closed. There are often one or two small spines on the upper corner of the gill cover.

Nassau Grouper (*Epinephalus*)



Courtesy N. Y. Zoological Society

The Sunfish Family (Centrarchidae): Fishermen apply the name Bass indiscriminately to basslike fishes belonging to other families as well as to the fishes named above. Such is the case with the Large-mouth Black Bass and the Small-mouth Black Bass, both of which actually belong to the Sunfish family (Centrarchidae), and the Channel Bass and California Sea Bass, which belong to the Weakfish family (Sciaenidae).

The Perches and Darters: These fishes of the family Percidae are plentiful in the fresh waters of the northern hemisphere. They have more vertebrae than the Basses, and only two spines in the anal fins. The majority of them are American. Both in Europe and in America, the Perches are popular game fishes. The Darters are characteristic of clear streams. They are small and brilliantly colored, with large fins. The largest Darter is about 6 inches in length.

The Cobia (Rachycentridae) is easily distinguished by its very definite markings—a conspicuous black stripe on either side of the body running from the tip of the snout to the tail and connected across the back of the head by a black saddle mark. The young of the Cobia presents a marked resemblance to the Shark Sucker (Echeneidae).

The Bluefish (Pomatomidae): This is a swift, carnivorous fish approaching the Mackerels in shape. The Bluefish, *Pomatomus saltatrix,* is one of our best known food and game fishes. The family contains only this one species.

The Triple-tails (Lobotidae): These are powerful, deep-bodied fishes. The anal and the dorsal fins extend fairly far to the back of the fin toward the tail, from which fact the name is derived.

The Berycids (Berycidae): These are chiefly deep-sea forms, near relatives of the Squirrel Fishes.



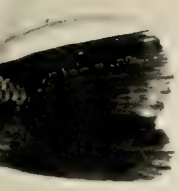
The Squirrel Fishes (Holocentridae): These are tropical fishes usually living among coral reefs. They are apt to be red, or red striped with silver or yellow.

Croakers and Weakfishes: The Croakers (Sciaenidae) are closely related to the true Basses, but differ in their small anal fins, in which the spines are reduced. In the long dorsal fin there is a deep notch between the spiny and the soft-rayed parts, but no gap between the parts at their base. A system of large pits on the top of the skull lodges sacs containing the sense organs of the lateral line system.

Local members of this marine family are the Weakfish, Channel Bass, Spot, Croaker, Whiting (*Menticirrhus*), and Sea Drum. The latter has strong pebbly teeth in its

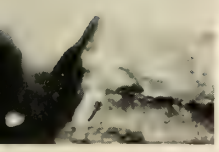
↓Sun Fish (*Lepomis*)





←Large-mouth Black Bass (*Huro salmoides*)

Courtesy N. Y. Zoological Society



↓Remora, showing the sucking disc on top of the head by which it clings to another fish

throat, with which it crushes shellfish. The grinding of these teeth makes a loud grunting sound.

SHARK SUCKERS, ETC. (Suborder Discocephali): The Remora, Echeneis, has a suction disc on top of its head, by means of which it clings to the sides of larger fishes, particularly the Sharks.

ANGEL, BUTTERFLY, AND SURF FISHES (Suborder Squamipinnes): The Angelfishes (*Holacanthus, Pomacanthus, Angelichthys*)



and their relatives the Butterfly Fishes (Chaetodontidae) have small nibbling mouths which act as pincers in plucking off small living organisms from the rocks and coral reefs. The great depth of the body and the strength of the fins give the fishes a very firm stance and power in this plucking. Their vivid colors and conspicuous, odd markings are in wide contrast to the usual silver or greenish-blue hue of open sea fishes. In the Butterfly Fishes, the teeth are very fine.

The Surf Fishes (Embiotocidae) are deep-bodied offshoots of the Bass stock. They develop the young within the body of the mother, a very unusual feature among Teleost fishes.

Fighting Fish, Climbing Perch, and Paradise Fishes (Suborder Labyrinthici): These fishes are so called because of the peculiar structure of the pharyngeal bones and respiratory apparatus. In these labyrinth-gilled fishes, the gill filaments discharge their normal function, but in addition, the fourth branchial arch is extremely developed and is provided with thick folds which form chambers where air is retained for respiration.

Betta, the Fighting Fish of Siam, is said to be used by the natives in the same

Angelfishes in a New York Aquarium tank

Courtesy N. Y. Zoological Society



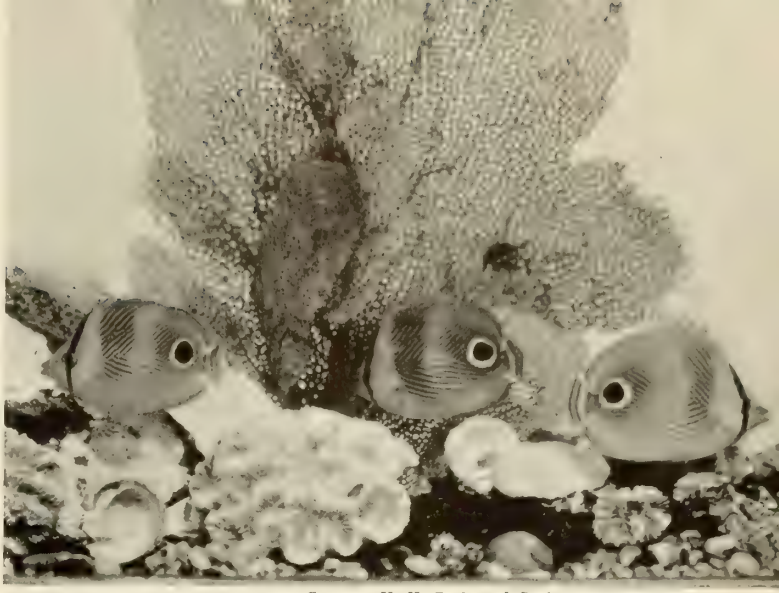
way that cocks are used for cock fights, only in this case the combat is held in a glass aquarium bowl. The various species of this genus are popular as aquarium fishes because of their incredibly varied and beautiful colors.

The Climbing Perch (*Anabas scandens*) has been credited with the ability to climb trees. This is an exaggeration, but the fish is indeed able to move rapidly overland by means of the mobility and the sharp spines of its gill cover, aided by the strong pectoral fins and tail.

The Gouramis (*Osphronemus, Trichogaster, Colisa*) and the Paradise Fish (*Macropodus*) also belong to this order. Almost all of the Paradise Fishes, the Gouramis, and the Bettas build a curious structure known as the "bubble nest." The "bubbles" are small quantities of air taken in the mouth of the fish and liberated at the surface of the water, making a raft several inches across, which is usually attached to a leaf or even to the side of an aquarium tank. The eggs are placed among these bubbles and hatch there.

Channa and *Ophicephalus,* the Snakeheads of Ceylon and China, are closely related and often assigned to the Labyrinthici, although their gill arrangements are not the same as those of the others of the suborder. The gill space, however, may be partly closed by a membrane, and the fish are known to survive long periods of drought.

Sergeant Majors, Beau Gregorys, and Cichlids (Suborder Chromides): The Sergeant Majors are active, bustling little fishes of the coral reefs. The Beau Gregorys and Sergeant Majors are somewhat the same in shape, but the Sergeant Major can be easily distinguished by the conspicuous dark bands across its sides while the Beau Gregory is very often half blue and half bright



Courtesy N. Y. Zoological Society

Butterfly Fishes in a New York Aquarium tank



Courtesy N. Y. Zoological Society

Male Siamese Fighting Fish with its bubble nest

The Sergeant Major

Courtesy N. Y. Zoological Society





Courtesy N. Y. Zoological Society

A South American Cichlid, *Aequidens latifrons*

yellow. Like the Cichlids and the Wrasses, these fishes have crushing teeth in the throat. The Sergeant Major's generic name, *Abudefduf*, comes from two Arabic words, *Abu* meaning "father" and *defduf*, a combined form used in emphasizing the word "flank" or "side"—in other words, prominent sides.

The Cichlids are especially plentiful in Africa, but are also found in brackish and fresh waters of Madagascar, Syria, India, Ceylon, and South and Central America, and as far north as Texas. These fishes provide a fine example of parental care (see page 10). These duties are performed by the females in certain species; in others by the males. But in either case, the eggs are sheltered in the mouth of the parent until the young can take care of themselves. However, the young are not always left

Hogfish: *Lachnolaimus*

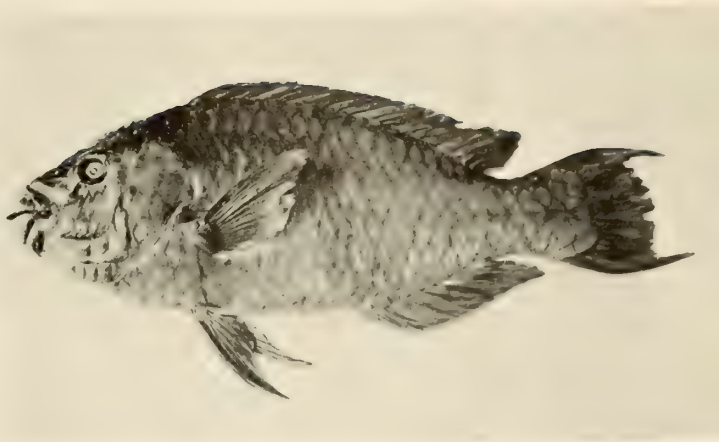
Courtesy N. Y. Zoological Society



entirely to their own devices, as the parent fish remains near them and drives off other fishes. Sometimes the male fish does this duty alone, and sometimes the male and female take turns.

Wrasses and Parrot Fishes (Suborder Labroidei): Apparently nature grew reckless when she colored the Wrasses and Parrot Fishes, for these are among the most bizarre sights that bewilder the eye of the visitor to undersea gardens in tropical waters. Only the Cunner and the Tautog, among the northern outliers of the family, have been toned down into sobriety and somberness in the chill waters of New England. The Cunner retains the loose, protruding lips and retreating forehead of its tropical ancestors, but the Tautog has acquired a short, stiff mouth, a prominent chin, and a generally determined countenance.

The Wrasses are more or less omnivorous, nibbling and biting with their strong incisors, and crushing with the remarkable pebble-coated millstones in their throats. In the Parrot Fishes, the front teeth have fused into a large beak, while the mill in the throat is surmounted by cylindrical teeth of oval or flattened section. The origin of this throat apparatus may be traced to the simple conical teeth clustered on the

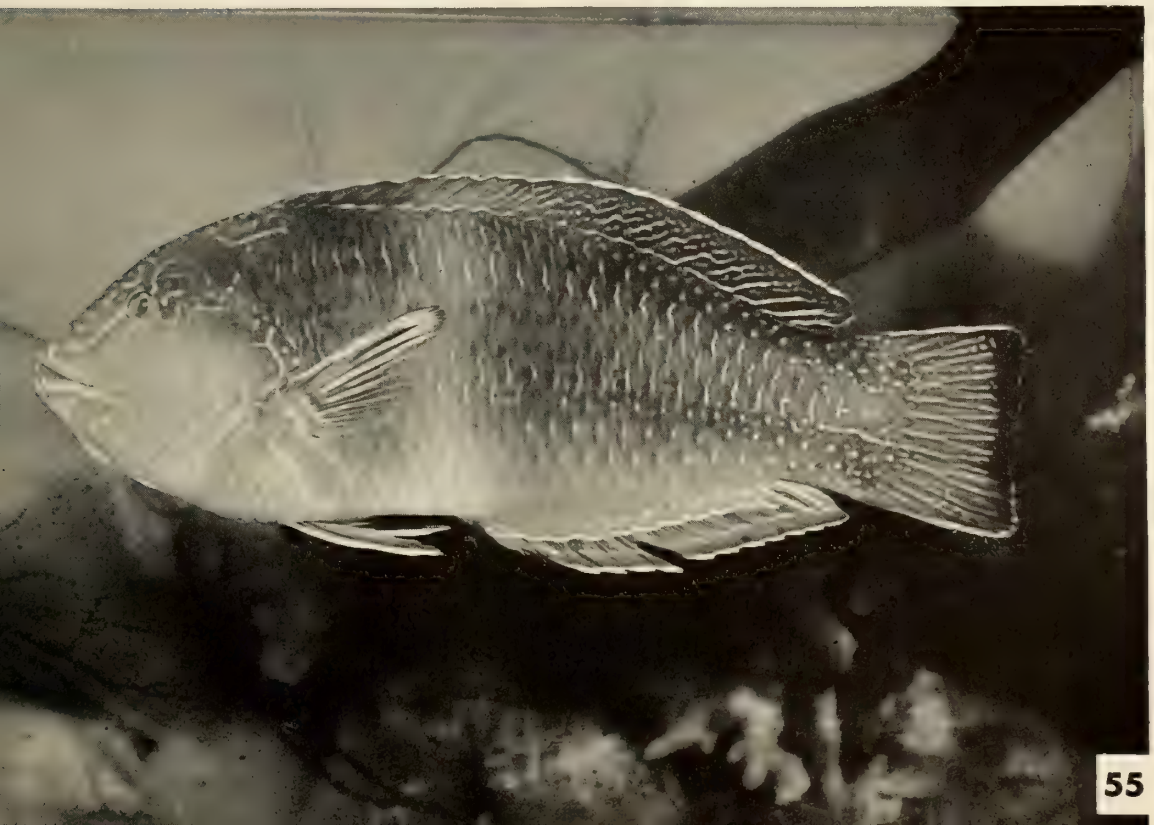


A.M.N.H. photograph

A Parrot Fish, *Scarus caeruleus*

The Pudding Wife (*Halichoeres pictus*). These fishes are wrasses. They are easily distinguished from parrot fishes because their front teeth are not fused into a beak

Courtesy N. Y. Zoological Society



surface of the gill skeleton in primitive Wrasses.

The varied colors of the Wrasses and Parrot Fishes are due to the high development of their chromatophores or pigment-bearing organs.

Sculpins, Gurnards, Scorpion Fishes, etc. (Suborder Scorpaenoidei): This group is generally known as the cheek-armored fishes because of the fact that one of the bones surrounding the eye is much enlarged and arches backward over the cheek so as to gain a broad contact with the forepart of the bony gill cover. Thus it forms the so-called "bony stay" that strengthens the skull in this group.

The Gurnards, or Sea Robins, with their broad heads enclosed in this bony shield, bear little resemblance to the Basses, yet they are connected with the primitive Sea Bass stock through the Sculpins and Rosefishes.

Most of the fishes of this group are marine forms, living either among the rocks or on or near the bottom, sometimes at considerable depths. The most primitive forms are the Rosefishes; the most advanced are the Gurnards. The first three rays of the Gurnards' breast fins are specialized as "legs." These rays are separated from the rest of the fin and from each other, and due to this specialization the movements of the fish among seaweed or along any surface much resembles walking on these fins.

In the Lumpfishes and the Sea Snails, the ventral fins are united and form a sucking disk by means of which these clumsy, slow-moving fishes cling to rocks.

The Platycephalids are a group of fishes from the East Indies and Japan. As their name implies, they have flattened heads, which present a curious resemblance to the heads of bottom-living forms of widely different groups, such as the extinct Ostracoderms (see Fossil Fishes, page 82) and the Armored Catfishes (page 38).

The Gobies (Suborder Gobioidei): The Gobies have pushed their way into all the seas outside the Arctic and Antarctic circles, and have representatives in the fresh waters of all parts of the world. The central form, *Gobius,* is not very different from the Johnny Darters of the Perch-Bass group, except that the ventral fins tend to form a sucking disc by means of which the fish can cling to rocks. In the Mudskipper, *Periophthalmus,* the pectoral fins are modified and strengthened so that they can be used as flippers, and the fish skips about on these over the mud flats of eastern tropical rivers. Its eyes are greatly enlarged and protruding.

In the Blind Goby of California, on the other hand, the eyes are reduced to mere vestiges, and the fish lives like a slug under rocks.

In size, the Gobies vary from the minute *Pandaka pygmaea* of the Philippines, which measures only 10 millimeters (less than ½ inch) in length, to *Eleotris marmorata* of Siam, which grows to nearly 3 feet. The Gobies differ from the cheek-armored group in lacking the bony stay of the cheek.

Blennies (Suborder Blennioidei): The Blennies are active little fishes living around rocky or coral reef shores. Certain Blennies, for instance the Lizard Skipper of Samoa, even leap from rock to rock at low water, in this respect paralleling the unrelated Mudskipper. Most of the Blennies are small, but there is one very large marine member of the family. This is the Sea Wolf, *Anarrhichas lupus.* This vicious fish has a long body and strong, tusklike front teeth, and is very hard to handle if caught. It also has large, rounded, crushing teeth on the roof



Courtesy N. Y. Zoological Society

Eighteen-spined Sculpin

of the mouth and inner side of the jaws, enabling it to devour crabs and shelled mollusks.

An outstanding character of the Blennies is the single-spined, small ventral fins. The Eel-pouts (Zoarcidae), elongate derivatives of the Blenny stock, have no spines in any fins except the dorsal.

THE WEAVERS (Suborder Jugulares): The Weavers are distant relatives of the perch-like fishes. Some of them have poisonous spines on the gill covers. The Electric Star-gazer of this group has a pair of powerful electric organs behind the eyes. In this case the electric organs have been derived from some of the muscles that formerly moved the eyeballs.

THE MACKEREL-LIKE FISHES (Suborder Scombriformes): Carangoids (Dolphins, Pompanos, Moonfishes, Jacks, etc.): The central type of these pearly, silvery fishes is the Pompano (*Trachinotus*), from whose narrow, well-rounded body we may derive, on one hand, the much deepened disc of



Drawing by D. Blakely

The Mudskipper (*Periophthalmus*) among mangrove roots: this strange fish skips about over the mudflats of eastern tropical rivers

A Jack (*Caranx hippos caninus*) taken off Talara, Peru, April, 1940

A.M.N.H. Expedition photograph



the Moonfish (*Selene*) and the Lookdown (*Vomer*), and on the other, the progressively elongate form of the Jacks (*Caranx*) and Amberfishes (*Seriola*).

The ornate Roosterfish (*Nematistius*) may be regarded as an Amberfish with an enlarged and plumed first dorsal fin. The Dolphin (*Coryphaena*), a very long-bodied offshoot from the Pompano stock, is famous for its brilliant and changing blue and golden hues. The dolphin of heraldry and sculpture is a composite of this fish and the true dophin, which is a kind of porpoise or toothed whale.

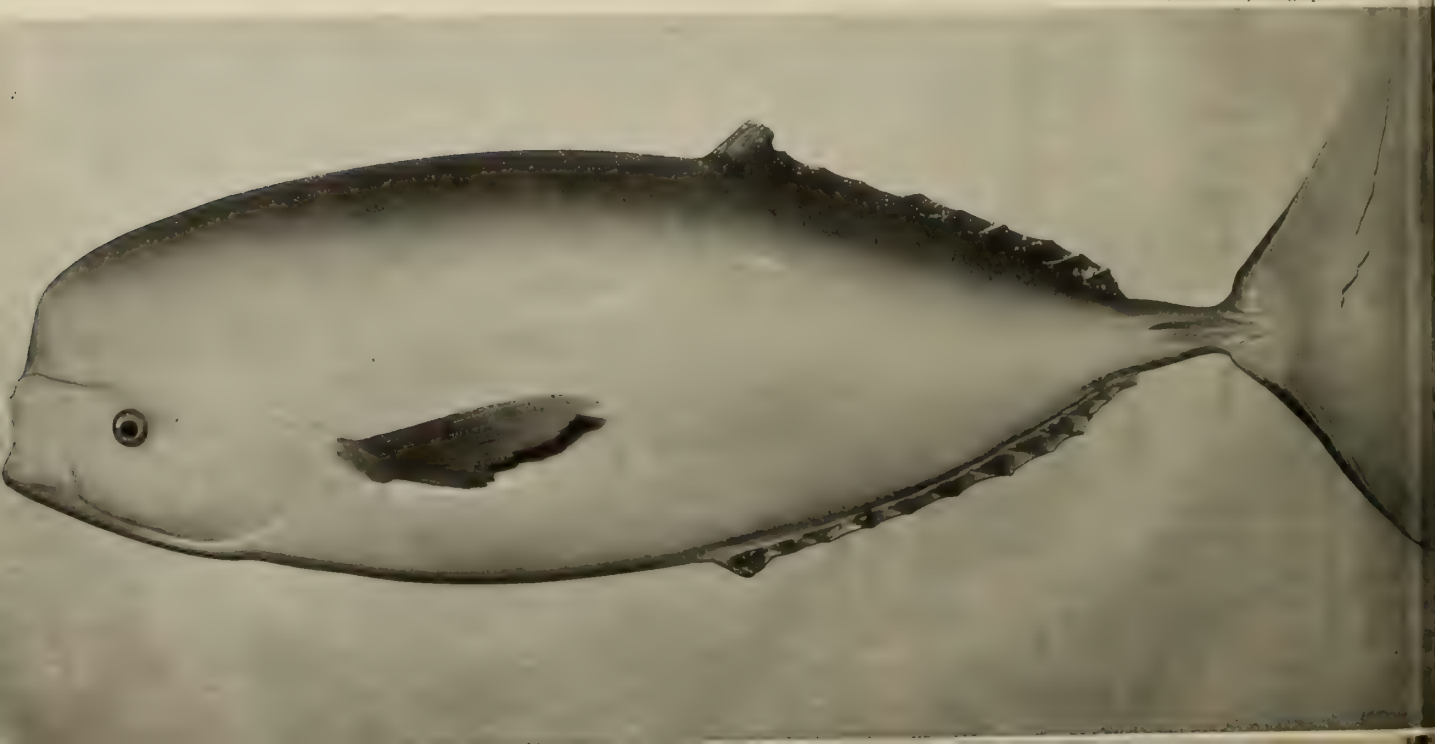
The Louvar (*Luvarus*): Only about 30 specimens of this rare fish have been recorded in the world, and these were chiefly from the Mediterranean and the Atlantic coast of Europe. In 1941, on the American side of the Atlantic one Louvar (represented in the photograph) was taken near East Hampton, New York, and another off Cayo Costa, Florida. From the Pacific Ocean one large Louvar came ashore on the coast of New South Wales, Australia, and two Louvars were taken off the coast of California. The bluish skin of the Louvar is covered with minute mushroom-like scales, which collectively suggest crusted pink snow. In general appearance the Louvar's body somewhat resembles the well-filled contours of the Bonito and Albacore, but it is distinguished by the very small size of its mouth and by the presence of a rounded hump on top of the head, which represents a forward extension of the base of the dorsal fin. The skeleton of the Louvar is extremely delicate and very specialized, but in many features it closely resembles the skeleton of the Albacore (one of the Mackerel group) and in others it recalls the Pompanos and Dolphins.

Mackerels, Tunas, Albacores, etc.: The Mackerel group represents one of the culminating phases in the evolution of the basslike fishes. Its more typical members are distinguished from the latter by the teardrop-shaped body, the delicate, thin boned skull, the absence of spines on the gill covers, the reduction of the scales, the presence of a horizontal keel at the base of the tail, and the symmetrical arrangement of rear fins above and below the horizontal axis.

The acme of speed, of "fineness," and of streamline form is attained by the Mack-

↓*Luvarus*, a large fish that appears to be covered with pink snow, owing to its minute mushroom-like scales

A.M.N.H. photograph



erels, Tunas, Bonitos, and their allies. In the Tunas, Bonitos, and Albacores the body is short and comparatively stiff, the tail large and crescent-shaped, but with a slender, strong base. These fishes often leap from the water like Dolphins. In the Mackerels, the body is more elongate. The Oil Fish, *Ruvettus,* is a deep water relative of the Mackerels. In the Cutlass Fishes (Gempylidae, Trichiuridae), the body has become eel-like, and the tail is reduced to a point.

Spearfish, Sailfish, and Marlins (*see also* Marine Gamefishes, page 75 ff.): The Sailfish *(Istiophorus)* and the Marlins *(Makaira*) are very closely related. The Marlin may be regarded as a Sailfish with a secondarily lowered dorsal fin and reduced ventrals. The Black Marlin of New Zealand, the giant of the family, reaches 14 feet 9 inches in length and 1226 pounds in weight. It is also the most specialized: the pectoral fins tend to be fixed in an extended position, the front end of the dorsal is more emphasized, and the stripes are lost in the generally black color. The vertebrae of the Marlins are greatly elongated and connected by long bladelike forward and backward projections which resist lateral bending and impart great resilience to the backbone.

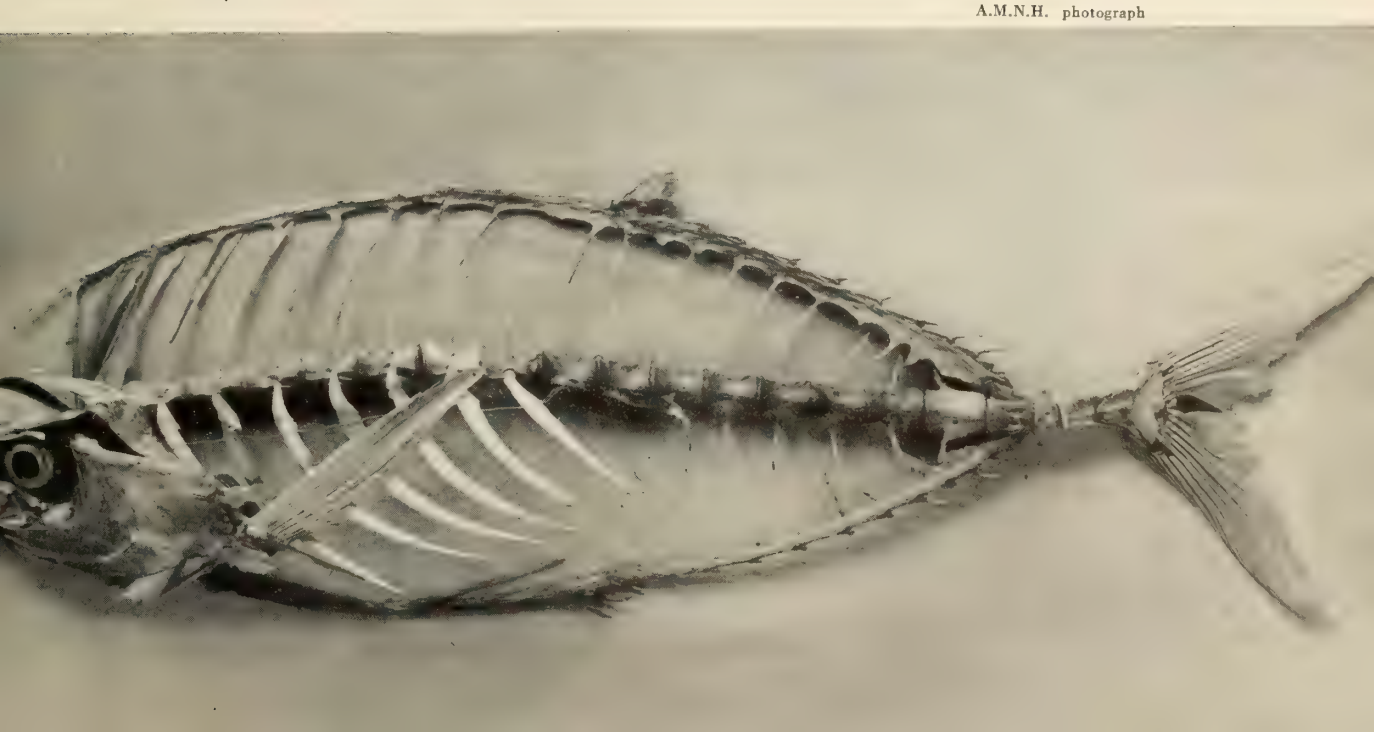
The Spearfish (*Tetrapturus*), a peculiar fish of questionable status, seems to be closely related to the Sailfish and Marlin.

The Swordfish (*Xiphias*): The Sailfish and Marlins, although often called "swordfishes," are widely different from *Xiphias,* the true Swordfish, which is described more fully on page 77. In *Xiphias* the pelvic fins have been completely eliminated and scales are retained only in the young (up to 11 pounds or so), whereas in the Sailfish and Marlin the pelvic fins are present, and long, thorny scales are retained in the adults. The vertebrae of *Xiphias* are short and much less specialized than those of the Marlins.

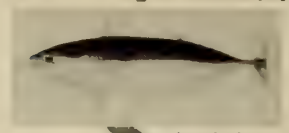
Acrotus (Suborder Stromateoidei): *Acrotus willoughbyi* is a strange, large fish of which a possible half dozen specimens have been captured, all of them from our Pacific coast. The specimen exhibited in the American Museum of Natural History was caught on hook and line from the Monterey breakwater, in May, 1940. It is related to the Butterfishes (*Poronotus*). Its skeleton has become largely cartilaginous.

The skeleton of *Luvarus* is extremely delicate and specialized

A.M.N.H. photograph

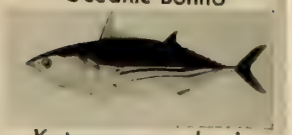


Japanese Frigate Mackerel



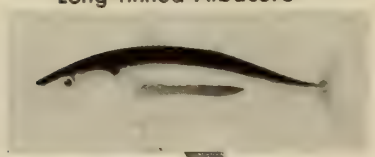
Auxis hira

Oceanic Bonito



Katsuwonus pelamis

Long-finned Albacore



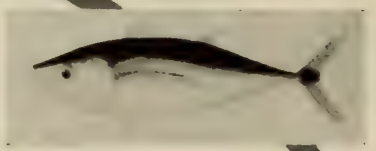
Germo germo

False Albacore



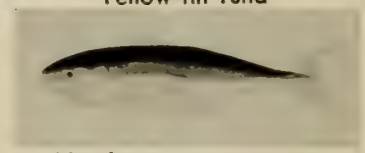
Euthynnus yaito

Mebachi



Parathunnus mebachi

Yellow-fin Tuna



Neothunnus macropterus

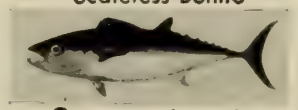
Tuna



Thunnus thynnus

1. The Mackerel series, culminating in the Albacores and Bonitos. (These are the swiftest and most active of all the Mackerels and have beautifully streamlined bodies.)

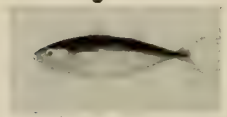
Scaleless Bonito



Gymnosarda nuda

2. The Spanish Mackerels and Wahoos, chiefly distinguished by their pointed snout, their long, low body, and long dorsal fin.

Herring Mackerel



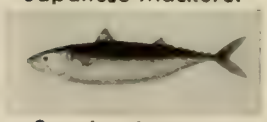
Rastrelliger chrysozonus

Oriental Spanish Mackerel



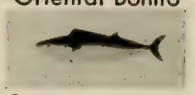
Cybium chinense

Japanese Mackerel



Scomber japonicus

Oriental Bonito



Sarda orientalis

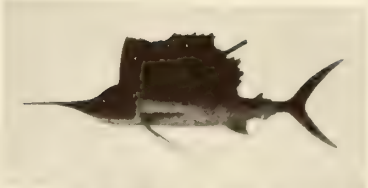
Two-lined Mackerel



Grammatorcynus bilineatus

. The Sailfish and Marlin, in hich the forepart of the skull produced into a long, sharply ointed sword or spear. In e Sailfishes, the dorsal fin is f enormous size. (The True wordfish [Xiphias] although mewhat resembling the Mar-ns, forms a very distinct branch ee page 59].)

Sailfish



Istiophorus greyi

Spearfish



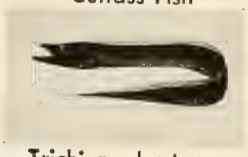
Tetrapturus imperator

Swordfish



Xiphias gladius

Cutlass Fish



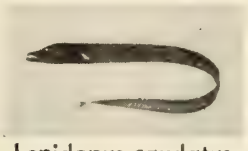
Trichiurus lepturus

Snake Mackerel



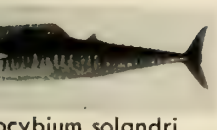
Gempyla serpens

Scabbardfish



Lepidopus caudatus

Wahoo



ocybium solandri

Domine



Epinnula magistralis

Oilfish or Escolar



Ruvettus pretiosus

4. The Escolar-Cutlass Fish line, which runs out into fierce, eel-like forms.

PEDIGREE OF THE MACKERELS AND THEIR ALLIES

This suborder divides itself into four principal lines

From an American Museum exhibit

Opahs, Dealfishes, Ribbonfishes (Suborder Allotriognathi):

Opah or Moonfish (*Lampris luna*): This rare visitor on our coasts is a round, iridescent fish with scarlet fins, and reaches a length of 6 feet and a weight of 500 to 600 pounds. The orb of its silvery body suggests the true Moonfish (*Selene*) of the Pompano family, but in the entire construction of its skeleton it differs widely from the Pompanos or any other of the mackerel-like fishes. It seems to be a gigantic relative of *Velifer* and may be remotely related to the Dealfishes (Trachypteridae). These have highly protrusile upper lip-jaws in which the premaxillae slide forward and outward, moving upon sockets in the maxillae.

Dealfishes (Trachypteridae): In these queer creatures the fanlike tail fin is set obliquely to the long axis and is directed upward and backward.

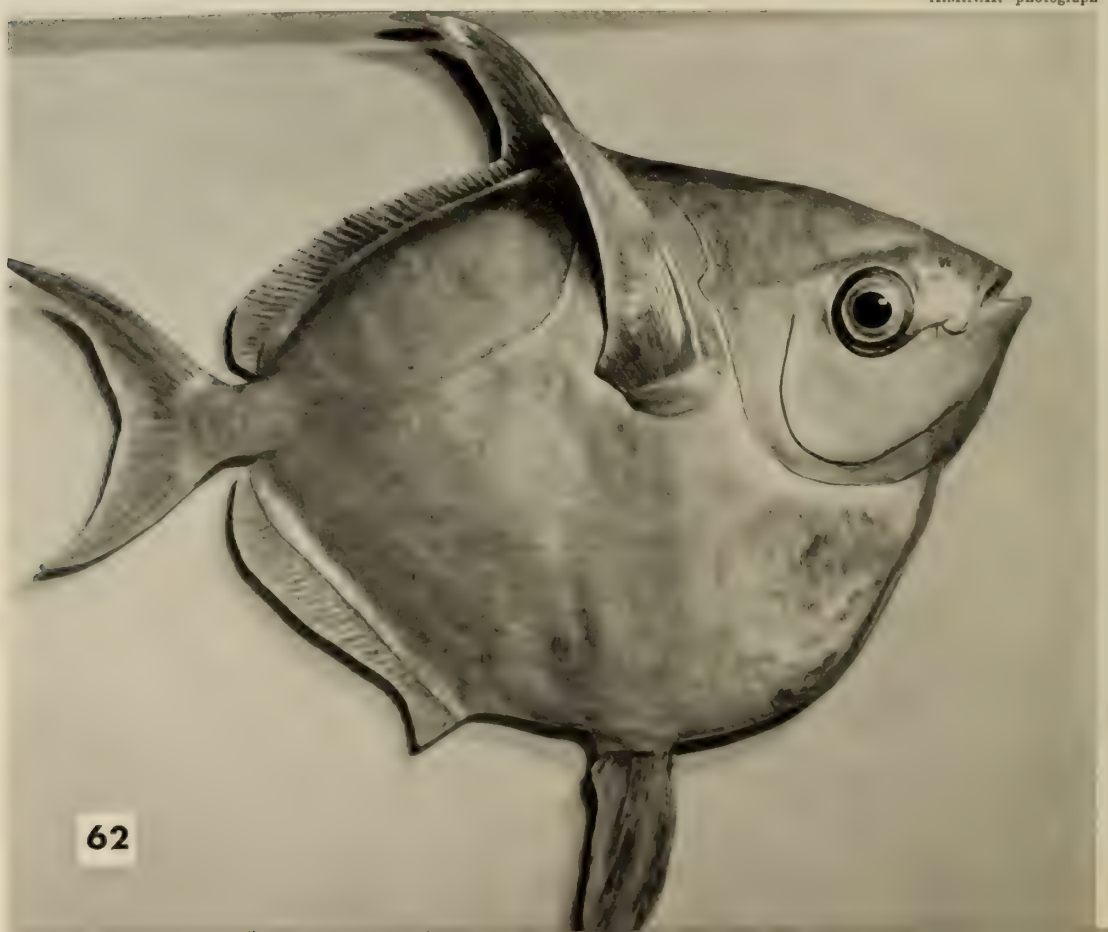
The Oarfish, *Regalecus glesne*, is a specialized Dealfish, strikingly colored. A life-size model is shown in the American Museum's Hall of Fishes. It is sometimes called the Sea Serpent Fish and may have given rise to some of the sea serpent stories.

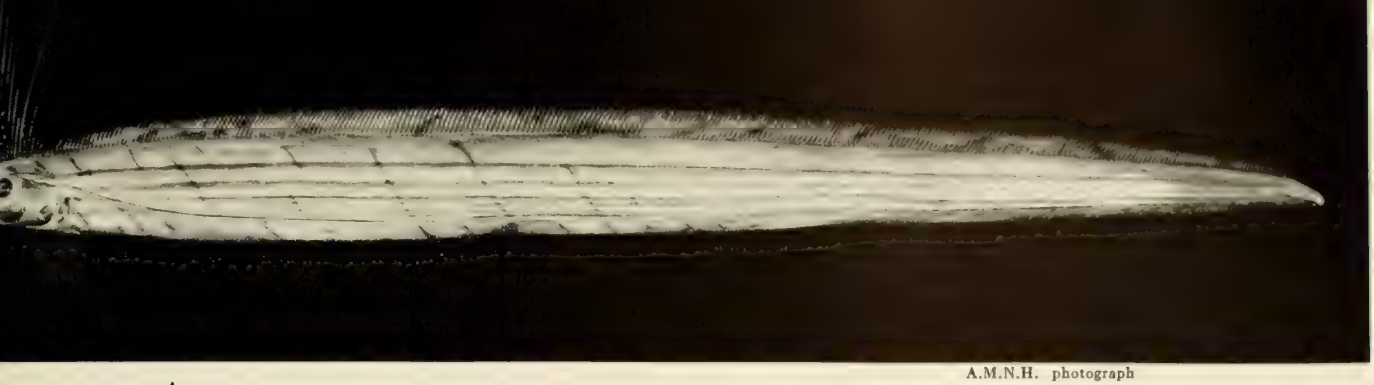
The fish is very long—it is said to reach a length of 30 feet—but the body is less than 3 inches thick. The body is bluish-silver, and just behind the head rises a high crest of bright scarlet fin rays. The mouth turns sharply upward. As is usually the case in fishes normally living at great depths, the skeleton of this fish is very delicate.

The Oarfish is rarely seen alive but has sometimes been taken when stranded. The one from which the American Museum model was constructed was caught off Otago, New Zealand. The fishermen, thinking it a sea serpent and somewhat alarmed, and also inconvenienced by its length, cut it in several pieces before bringing it ashore.

The Opah, or Moonfish (*Lampris luna*)

A.M.N.H. photograph





A.M.N.H. photograph

The Oarfish (*Regalecus glesne*), a 30-foot fish sometimes called the Sea Serpent Fish. It probably gave rise to some of the tales of sea serpents

ORDER ANACANTHINI
(Cods, Hakes, Grenadiers, etc.)

These are highly specialized offshoots of the spiny-finned order, and in many respects they are degraded forms. Even in the rat-tailed Grenadiers (Macrouridae), deep-sea fishes which are less specialized than the Cods, the true tail fin has been lost and the hind end of the body is prolonged into a trailing wisp. In the Cods and their allies, the tail, while outwardly not unlike that of more normal fishes, appears to be merely an imitation, fashioned from the rear parts of the elongated, subdivided soft dorsal and anal fins, as shown by the structure of the bony rods supporting the tail. In most of the fishes of this order the ventral or pelvic fins are normal, but in the fish known in some regions as the Hake and in others as the Ling (*Phycis*), the ventrals have been reduced to greatly elongate feelers.

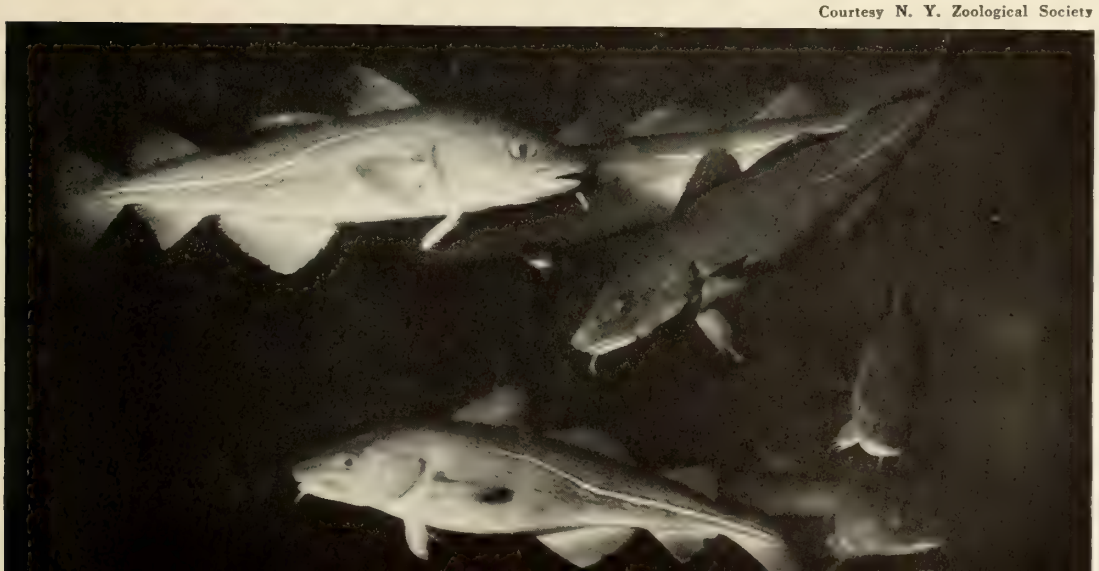
The group is essentially marine and ranges from the greatest depths to the shallower waters of the coastal belt.

The abundance of some of these fishes is truly astounding; 19,634,000 pounds of Cod were received in New York City alone in 1943. The roe of a 75-pound Cod contained, according to a careful estimate, no less than 9,100,000 eggs!

Long before the landing of the Pilgrims at Plymouth, boats had come from Europe to the New England coasts and north to the Grand Banks to fish for Cod. These fisheries, which have now developed into a huge industry, were of the utmost economic importance in the life of the early settlers in New England. They center at present in Boston and in Gloucester, Massachusetts. Before the second World War, cod fisheries were also a large industry in France, which sent a famous fleet to the Iceland fishing grounds, and in Norway, which carried on big fisheries in the Lofoten Islands.

Cod: an abundant and commercially important fish. A 75-pound cod can lay over nine million eggs

Courtesy N. Y. Zoological Society



ORDER HETEOSOMATA
(Flatfishes)

In this group belong the Flounder, Halibut, Turbot, etc.—fishes which habitually lie on one side on sandy bottoms. They have been derived from deep-bodied fishes not unlike the John Dory (*Zeus faber*). The fossil fish, *Amphistium*, of the upper Eocene period, which has been regarded as an early member of the Flatfish order, was a deep-bodied, symmetrically built form which had not yet become twisted for lying on its side.

Migration of the Eye in Flatfishes: When the Flatfishes are hatched, the young are normal in appearance, with even coloration and an eye on either side. They swim in a normal way. However, as the fish begins to develop, it tilts over toward one side, and finally becomes adapted for resting and swimming in this position. Meanwhile the color on the more exposed side grows deeper, while that on the under side remains light. The eye of the down-turned side migrates over the top of the skull so that, in the adult, both eyes lie on the upper side of the head. In most of the Flounders, the eyes and color are on the right side; in the Turbots, on the left. The mouth also is partly twisted onto the upper surface.



After Jordan and Evermann, 1900

↑Northern Fluke (*Paralichthys dentatus*). Its eyes are on either side of its head in youth, but as in other flatfishes, one of them migrates as the fish grows until they are both on the top side

ORDER PEDICULATI
(Frogfishes, Batfishes, Anglers)

The Frogfishes (Antennariidae) are small, active fishes, the best known of which



A.M.N.H. photograph

←The Sargassum Fish: an amazing example of natural camouflage. The fish lives among the seaweed of the Sargasso Sea, as shown in this museum exhibit

is probably the Sargassum Fish, *Histrio histrio.* Its shape and color make it very difficult to distinguish from the masses of weed in which it moves about. Like the other fishes of this order, it has a peculiar joint at the base of the pectoral fins. The front part of the dorsal fin is prolonged on top of the head above the upturned mouth; and one of the fin rays, which looks like a slender fishing rod, can be moved by small muscles at its base. The tip bears a bit of the fin web and serves as a bait or lure for the small crustaceans on which the Frogfish feeds.

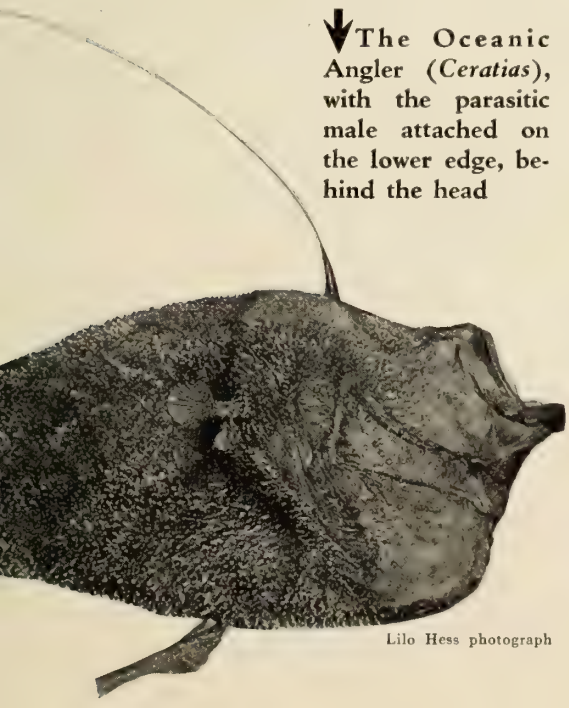
The terrible living trap set by the Anglerfish (*Lophius*) lies in wait for the unwary fish that stops to examine its dangling bait. This trap consists of the sharp-toothed jaws and cavernous interior of its enormous mouth, and just as in the Frogfishes, the bait is a bit of skin floating from the top of a movable fishing rod—an enlarged and separated ray of the dorsal fin.

In the Oceanic Deep-Sea Anglers (Ceratiidae), which live in abyssal darkness, the lure or "bait" is supplied with a luminous substance (luciferin).

The males in several species of Oceanic Anglers are of extremely small size and live dangling like pendants from the side of the head of the gigantic females. The American Museum exhibit shows the replica of a cast in the British Museum (Natural History) of *Ceratias holboelli,* the Oceanic Angler, with its parasitic male. We quote from the original British Museum label:

"The female Angler Fish with attached parasitic male from which the original cast was made, was taken near Iceland. It is 40 inches long and has a male 4 inches long attached in the mid-ventral line a little behind the head. Unlike the female, the male has no fin ray on the head; its mouth is small, toothless and closed in front, and the alimentary canal is vestigial. Fleshy outgrowths from the face of the male unite in front of the mouth and face with a projection from the skin of the female. Dissection reveals that both the outgrowth from the male and the projection from the female are formed of fibrous tissue with numerous small blood vessels. The union is complete so that it is impossible to say where one fish begins and the other ends. The blood system appears to be continuous with that of the female, from which the male derives its nourishment. The Ceratioids are unique among backboned animals in having dwarfed males of this kind."

The habits and conditions of life of the Ceratioids—few in number, solitary, slow swimmers, floating about in the darkness of the middle depths of the ocean—would make it difficult for a mature fish to find a mate. It is possible that the males, as soon as they are hatched, at which time they are relatively numerous, are attracted by the females' luminous "bait" and if they find one, become attached to her and remain attached for life. Probably the male first nips a piece of skin of the female, and then its lips fuse with the papillae so formed.



The Oceanic Angler (*Ceratias*), with the parasitic male attached on the lower edge, behind the head

Lilo Hess photograph

THE BATFISHES (Ogcocephalidae) are small, very much widened relatives of the Frogfishes. *Ogcocephalus vespertilio* occurs from the West Indies to Florida and is occasionally found as far north as New York. It has an elongated, narrow, and rather pointed "snout," which is really not a snout but a forwardly grown hump projecting above and in front of the vestigial "bait." The pectoral fins are greatly enlarged and project forward and outward like frogs' legs. The pelvic fins, although smaller, are also leglike. They are fastened to the underside of the huge pectoral girdle in front of the pectoral fins. Presumably these strange fishes can hop along the bottom of the ocean and can also swim by flapping their pectoral fins. The Batfishes are clearly connected with the Frogfishes by the deep-sea fish *Chaunax*. In this fish the bait or line is already enclosed by the overgrown dorsal hump, which is the greatly enlarged spine of the front portion of the dorsal fin, but the rest of the body is more like that of the Frogfishes.

THE ANGLER group may be regarded as excessively specialized relatives of the Blennies (page 56).

A family of depressed, scaleless bottom fish, known as the Toadfishes (Batrachoididae) is in some respects intermediate between the Blennies and the Anglers.

ORDER PLECTOGNATHI
(Surgeons, Triggerfishes, Puffers, etc.)

THE SURGEONFISHES (Acanthuridae) are so called because they carry sharp knifelike spines one on either side of the tail base. These spines are actually greatly enlarged scales. They are sometimes depressible in a groove. The fish seems to be able to give a vicious sideswipe with its tail. In *Xesurus*, a Pacific fish, the knife is replaced by three or more forwardly directed spikes. The very small but strong jaws are armed with nibbling teeth and set at the end of a downwardly produced muzzle. The Surgeonfishes are a specialized offshoot of the basslike fishes (Percoids). They may be remotely related also to the Angelfishes (Pomacanthidae) and the Butterfly Fishes

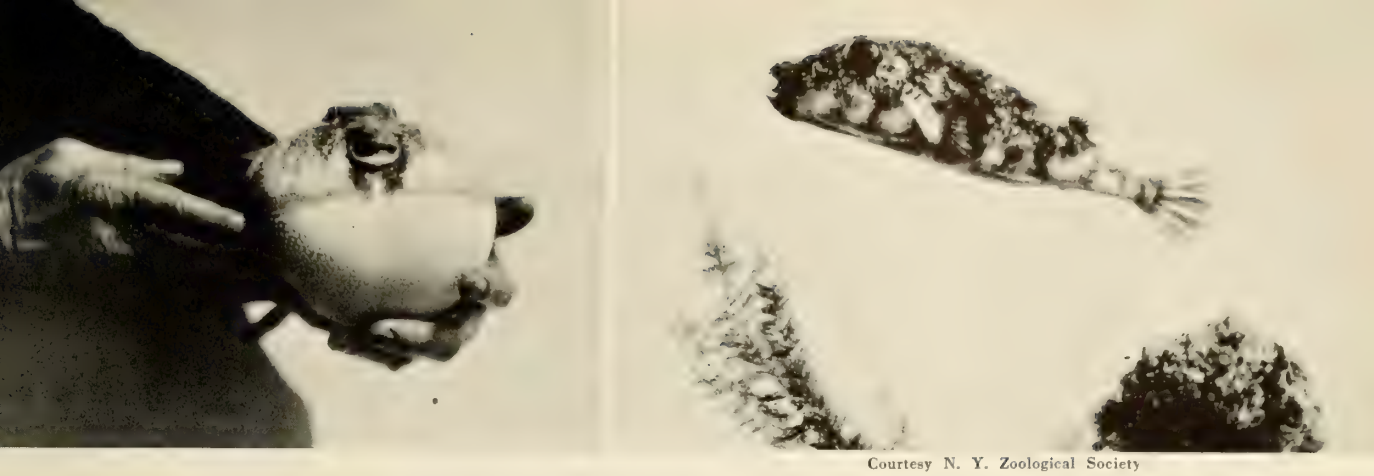
If a larger fish tries to swallow it, the Triggerfish can lock the large spike behind the eye in an erect position. It does this by pulling the small one just back of it into place



Surgeonfish, showing horizontal knifelike spine on the stem of the tail

Photographs courtesy N. Y. Zoological Society





Courtesy N. Y. Zoological Society

The Puffer inflated and deflated. It pumps itself full of water as a method of defense. Both photographs are of living fishes in the New York Aquarium

(Chaetodontidae) and more nearly related to the Moorish Idols (Zanclidae) and the Triggerfishes (Balistidae).

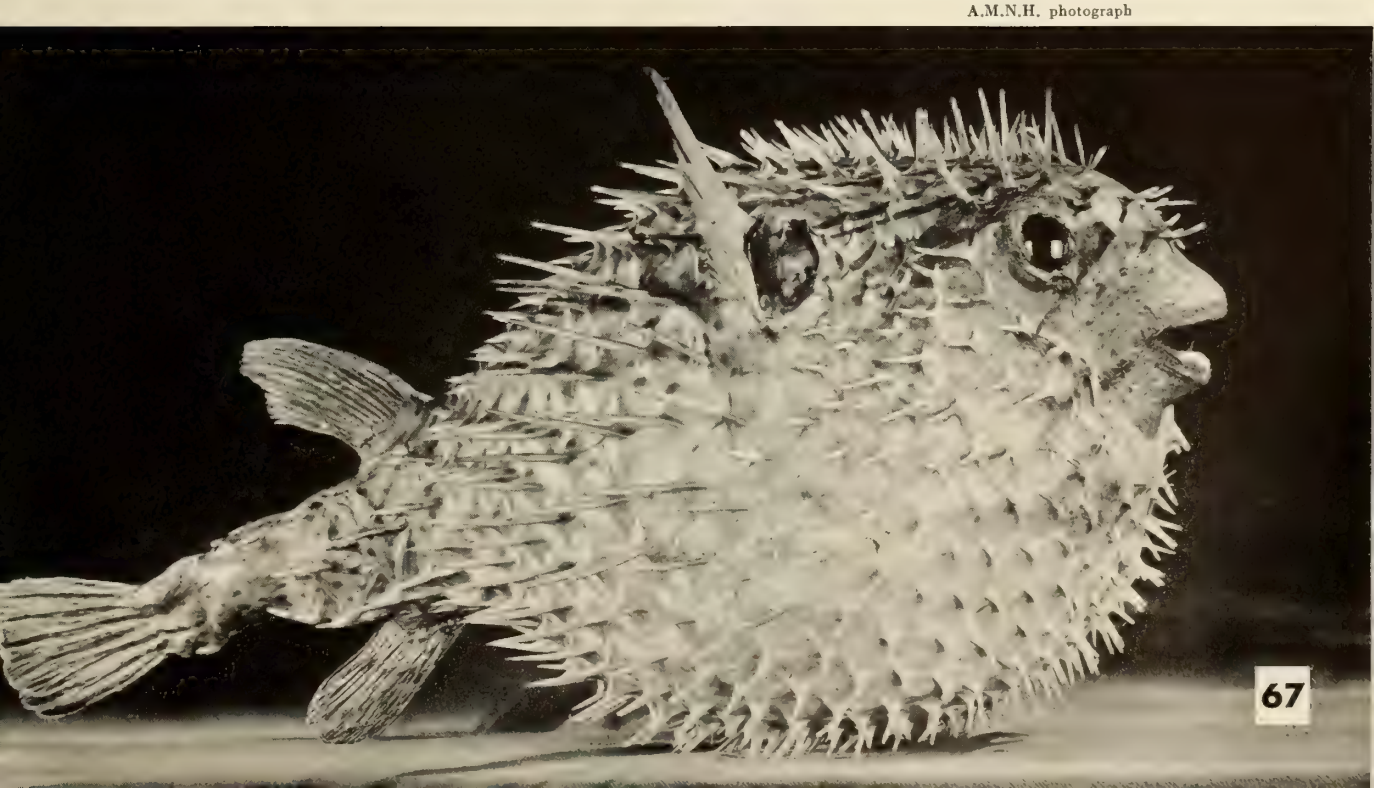
THE TRIGGERFISHES (Balistidae): The Triggerfish is an inoffensive fish which swims around coral reefs searching for something good to nibble. If a large fish attempts to swallow him, he erects the tall spike or "trigger" on his back, stretches his leathery skin and awaits developments. The real trigger is a small spike, behind the larger one. When it is pulled into place by the muscles beneath, it serves to lock the large spike in an erect position so that it cannot be lowered until the "trigger" is withdrawn. The Queen Triggerfish, *Balistes vetula*, one of the larger Triggerfishes, is common about Florida and the Bahamas. It is very brilliantly colored and capable of considerable and rapid color change. The Triggerfishes are more specialized relatives of the Surgeonfishes.

THE FILEFISHES (Monacanthidae) are closely related to the Triggerfishes, but they have only a single spine on the back and lack the trigger arrangement of the Balistidae.

THE TRUNKFISHES (Ostraciidae) are en-

The Porcupinefish (*Diodon hystrix*) adds bristling spines to its inflationary defense

A.M.N.H. photograph

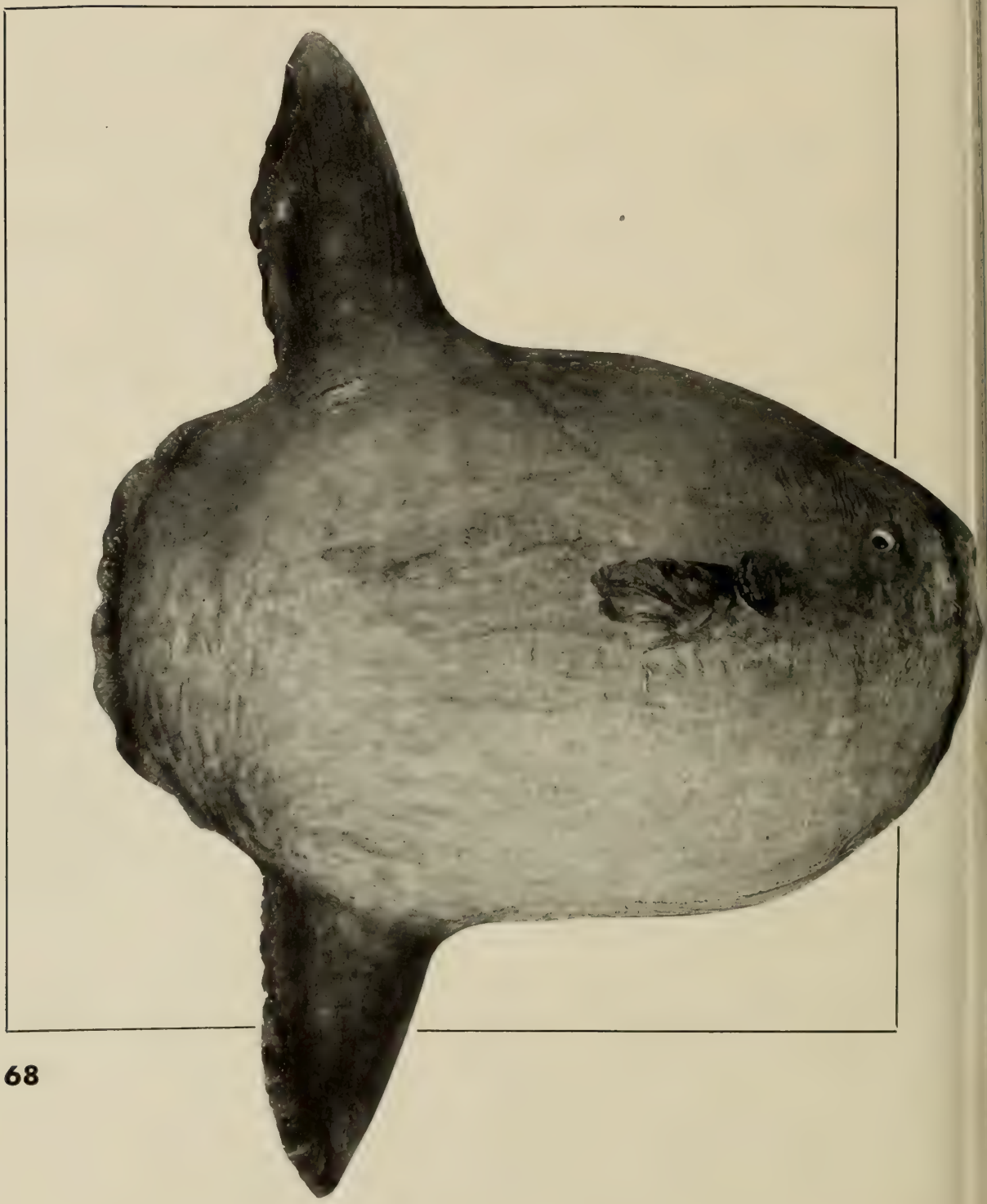


cased in a solid shell of derm-bones. They are incapable of any body movement except in the fins. Even the root of the tail is enclosed in its own bony tube.

THE PUFFERS AND PORCUPINEFISHES: The frog that tried to swell to the size of an ox finds a certain parallel in the Puffers (Tetraodontidae) and Porcupinefishes

A 2000-pound Ocean Sunfish (*Mola mola*) in the Zane Grey Gamefish Collection at the American Museum of Natural History

A.M.N.H. photograph



(Diodontidae). Unlike the frog, however, they do not burst, but readily deflate themselves before their elastic limit is reached. They puff themselves out by pumping water in through the mouth by the action of certain specialized throat muscles. Apparently it is as hard for a larger fish to bite an inflated Puffer as it is for a boy to bite an apple floating in the water.

In both Puffers and Porcupinefishes, the front part of the jaw is modified into powerful nippers for biting and crushing resistant objects. In the Puffers, the right and left sides of the beaks are separated; in the Porcupinefishes they are fused.

The Ocean Sunfish (*Mola*)[1] is a gigantic relative of the Porcupinefish. Its body is enveloped in rubbery skin from 2 to 2½ inches thick. Bending of the body is therefore limited. Movement is largely confined to side-to-side waving of the high median fins and gentle undulations of the scalloped border of the tail, which serves also as a rudder. Lateral stability is aided by the wide, more or less truncate, pectoral fins.

The most striking characteristic of the skeleton is the great reduction of bony tissue. Ossification is so weak that the material when cut with a knife resembles cartilage. The brain is extremely small for the size of the skull and brain cavity.

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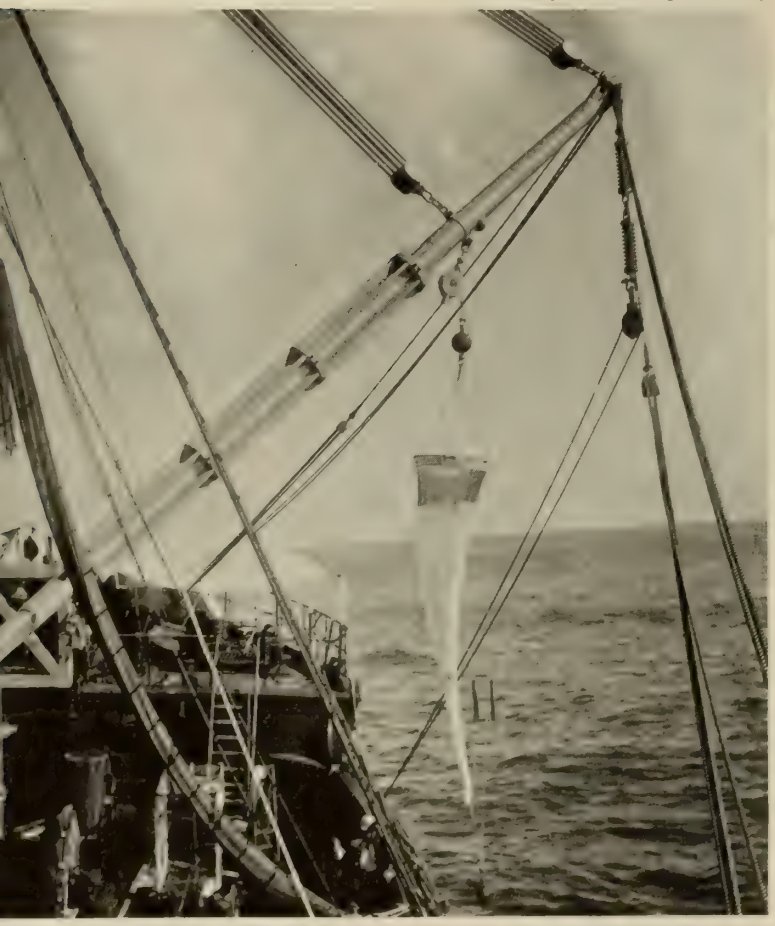
[1] Gregory, W. K., and H. C. Raven: Notes on the Anatomy and Relationships of the Ocean Sunfish (*Mola mola*). *Copeia,* 1934, no. 4, pp. 145-151, 1 pl.

Deep-Sea Fishes

Netting operations on the "Arcturus." In 1925, the Arcturus Expedition sent out by the New York Zoological Society, collected numerous specimens of the incredibly fragile fishes that live in the depths of the ocean a mile or more beneath the surface. Every square inch of their bodies at that depth is exposed to a water pressure of over a ton.

The American Museum's exhibit contains some of the actual specimens, and also a series of deep-sea groups, material for which was gathered near the Galápagos Islands

Courtesy N. Y. Zoological Society



Wandering Ghosts in the Country of Perpet Night. These two groups show the ocean floor, 10 fathoms down, where deep-sea fishes wander abo



ched skeleton of a whale. In this realm of total
s, the water pressure is over a ton and the
ture around freezing

A.M.N.H. photographs



Little Sea Devils. These are some of the small Oceanic Anglers. Their mouths are open to catch the prey attracted by the bit of luminous skin at the end of their fishing-rod appendages





←The Bathysphere. This steel sphere was first used by Dr. Beebe off Nonsuch Island, Bermuda, in the summer of 1930. It is so made and equipped that two investigators have descended in it to over 2200 feet below the surface of the sea, to observe the life in those depths through its fused quartz windows

↓The Black Pirates. These degraded Eels have lost almost everything but their voracious appetites, for which their enormous mouths and elastic stomachs are well equipped. One of them has just swallowed a fish larger than himself

A.M.N.H. photographs



Luminous Fishes

↓ "The Dragon Strikes": A group of Big Heads being pursued by the gleaming, iridescent Dragonfish, *Chauliodus*

A.M.N.H. photographs



→ "Blazing Jewels." The Jewelfishes (Myctophids), flashing and luminous, live far down where the last feeble light merges into blackness



↑ "Neptune's Fireflies": Lanternfishes, with rows of phosphorescent spots sparkling on their sides, pursued by *Astronesthes*





A.M.N.H. photographs



Reef Fishes

←The Great Barrier Reef. The northeast coast of Queensland, Australia, is bordered for more than 1000 miles by a chain of coral islands, lagoons, and reefs. At the southern end of the Barrier lies Heron Island, where the material for this group at the American Museum was collected. The generally flat top of the coral banks is determined by the low tide level, since the coral animals die if exposed long to the air.

The branching and massive corals afford shelter and subsistence to a rich fauna of crustaceans and the small, brightly colored fishes who feed upon them

↙ A Whale Shark propels its huge checkerboard body towards us in the American Museum's exhibit of the waters off Bimini. This small island at the northern end of the Bahamas is almost level with the ocean. Where the shallow sandy bottom deepens to form pools, Blueheads, Sergeant Majors, and Demoiselles dart in and out among coral caverns. Grunts, Queen Triggers, and an occasional Barracuda swim about among the purple Sea Fans; and a dark Sting Ray may sometimes be seen lying half-buried in the sand.

Bimini is within five miles of the Gulf Stream and a short distance from the deep submarine valley known as the Tongue of the Ocean



Marine Game Fishes

↓Zane Grey with a 1036-pound Tiger Shark caught in Australia. To Zane Grey we are indebted for the nucleus of the American Museum's Game Fish Exhibit which originally consisted of Dr. Grey's own rod and reel catches. These are now shown in a separate section of the Game Fish Exhibit





Michael Lerner with two rod and reel catches taken off Tocopilla, Chile, on the Michael Lerner American Museum Chile-Peru Expedition of 1940. The Striped Marlin (*left*) weighed 410 pounds, and the Swordfish 608 pounds. Both fishes occur in great numbers off the northwest coast of South America. Mr. Lerner is the donor of the Mako Shark, Tuna, and Blue Marlin groups shown in this section

Habits and Life History of the Swordfish

The International Game Fish Association has installed in the Game Fish Section of the American Museum's Hall of Fishes an exhibit illustrating the life history of this fish, from the tiny egg to the huge adult.

The Swordfish may be readily distinguished from the Marlin by the absence of pelvic fins and, in the adult, the absence of scales. Swordfish that have been hooked or harpooned sometimes follow the line back and dash themselves at the boat, occasionally piercing the wood with their sword. One of these fishes has been known to penetrate an 18½ inch plank, 14½ inches of which was oak.

Commercial fishing for Swordfish is carried on both for the very palatable flesh and for the high vitamin content of the oil from its liver.

There are also commercial marlin fisheries in some parts of the world, although the flesh is generally considered edible only if smoked. The Striped, Black, and Silver Marlins frequent the Pacific; the White and Blue are limited to the Atlantic.

The Sailfish. This very beautiful exhibit, presented to the American Museum by Mr. and Mrs. Keith Spalding, represents a hooked Pacific Sailfish clearing the water off the rocks of Cape San Lucas, Lower California

A.M.N.H. photograph



The Blue Marlin, one of the Atlantic Marlins: a specimen taken on an American Museum expedition in the cobalt waters of the Gulf Stream off Bimini, Bahama Islands

A.M.N.H. photograph



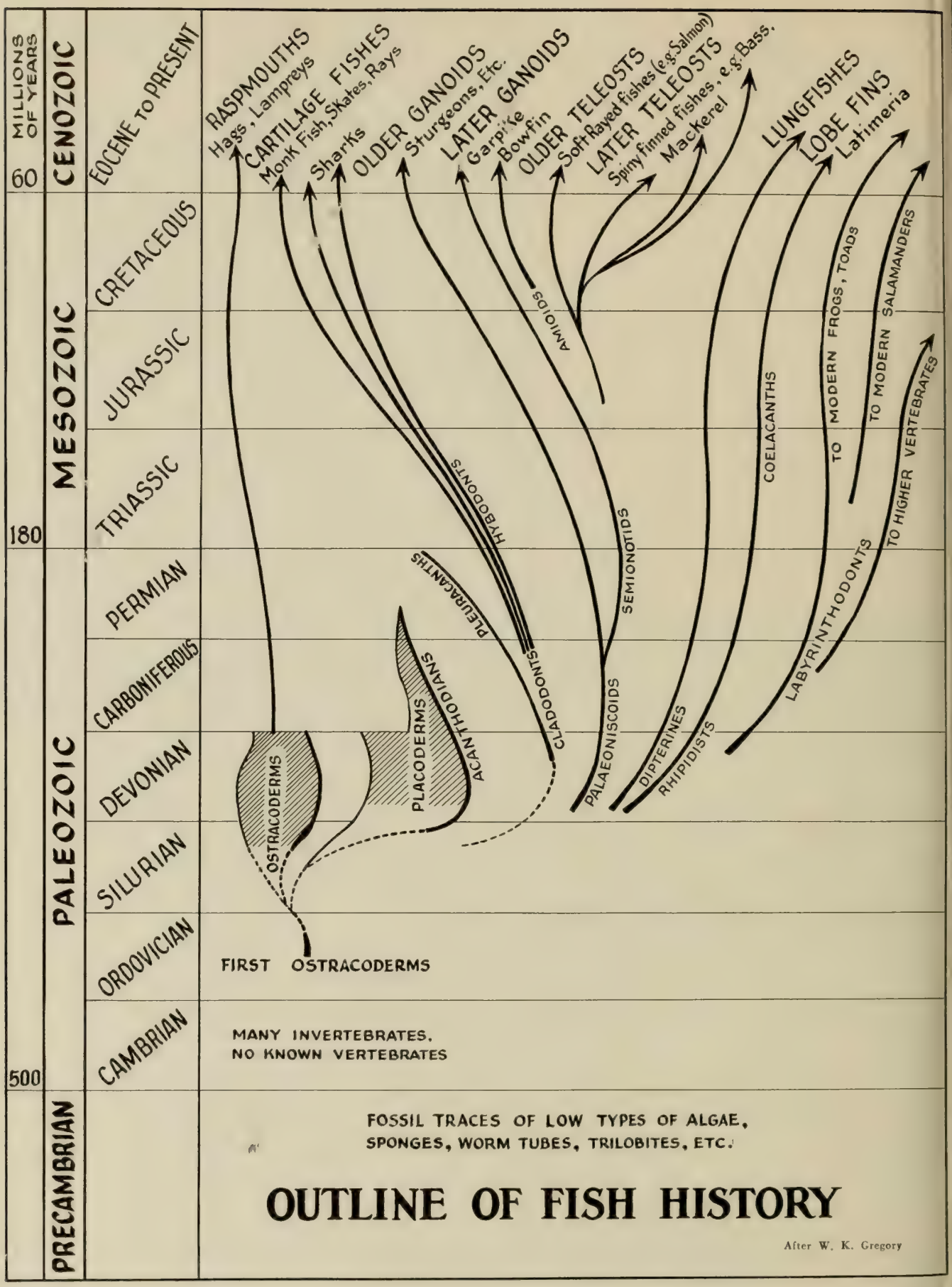
➔A Bluefin Tuna. One of the favorite fishing grounds for this fish, both commercially and for sport, is off Wedgeport, Nova Scotia, where this specimen, exhibited in the American Museum's Tuna Group, was taken



➘The Mako Shark is one of the most highly prized of all hard-fighting game fishes. The specimen shown here weighed 602 pounds. The Mako is probably the swiftest of all sharks, and its spectacular leaps are said to reach as high as the masthead of a launch

A.M.N.H. photographs





OUTLINE OF FISH HISTORY

After W. K. Gregory

Fossil Fishes

The Bashford Dean Memorial Exhibit

Bashford Dean (1867-1928), the founder and first curator of the American Museum's Department of Fishes, was one of the great leaders in the study of fossil fishes and of the development of recent fishes.

This exhibit is based on a selection from a small part of the Museum's extensive collections of fossil fishes. It includes among others, (1) fishes of Devonian and Carboniferous ages, which came to the Museum through Dr. Dean's friend and teacher, Dr. John Strong Newberry, (2) fossil fishes of Upper Cretaceous age from Mt. Lebanon, Syria, and (3) huge fishes from the chalk formations of Kansas.

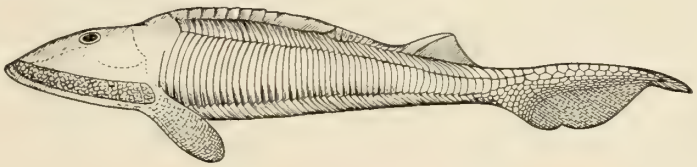
The inconceivably vast stretch of time suggested by the adjacent chart, "Outline of Fish History," may at first baffle the imagination. Our first reaction to such data is the question "How are such stupendous figures of geologic time computed?"

The answer, in detail, is contained in a volume entitled "The Age of the Earth," prepared under the auspices of the National Research Council. This volume contains a description of methods employed by physicists in measuring the ages of rocks containing pitchblende (uranium) and other radioactive substances giving off radium rays and other forms of radiant energy. No matter what degrees of heat or pressure are applied in the laboratory, these rocks continue to emit radiant energy according to their original rates.

Briefly stated, pitchblende gives off radium rays and other radiations in a slowly descending series, extending over immense periods of time. The residue, which has lost its radiating power, is lead. The mass of the lead, when measured, becomes a factor in a formula for measuring the age of the rock. The radium-bearing rocks have welled up from great depths and solidified at various levels in the entire series from older to younger rocks. Their computed ages range from about 1½ billion years down to 37 million years or less.

The Oldest Known Vertebrates

The Cephalaspids had shieldlike heads and were probably slow-moving, bottom-living forms

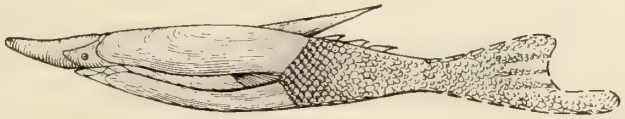


A Hemicyclaspis (After Stensiö)



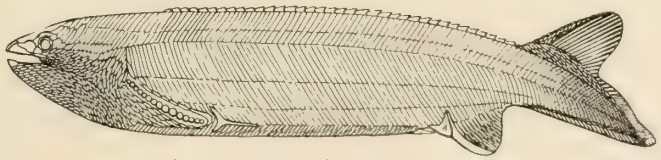
B Anglaspis (After Kiaer)

The Pteraspids were more fishlike and swift-swimming than the Cephalaspids



Pteraspis (A composite from Powrie & Lankester, and E. I. White)

The Anaspids were elongate, somewhat herringlike forms



D Pharyngolepis (After Kiaer)

The Oldest Known Fossils

(THE OSTRACODERMS)

The oldest known fossilized remains of fishes have been found in rocks of Ordovician age, estimated to be more than 400 million years old.

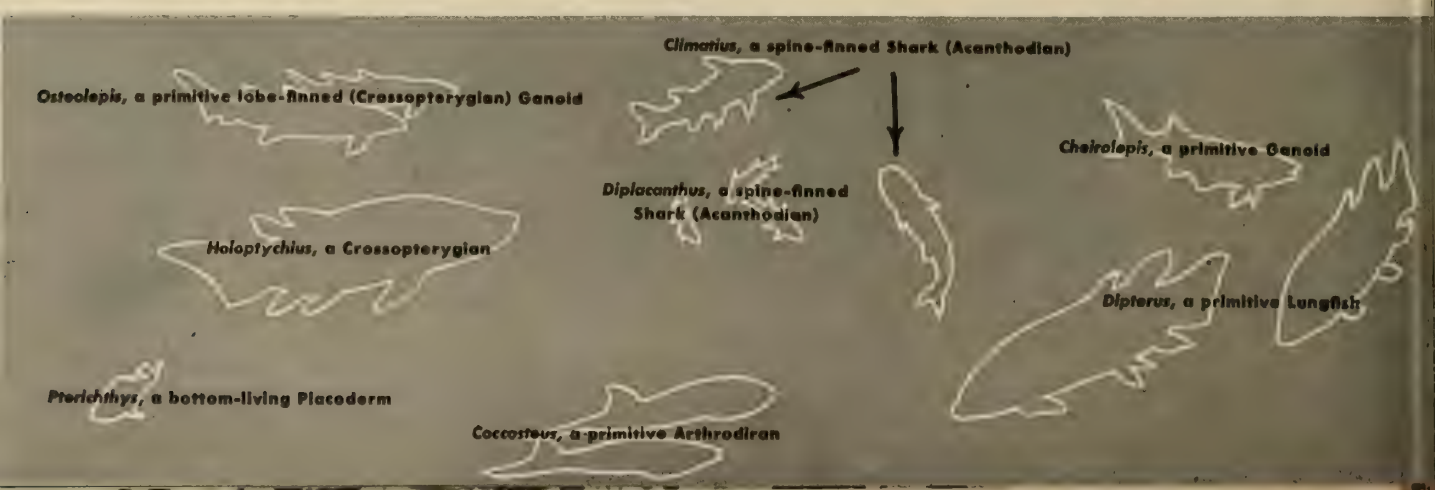
These primitive fishes were already built upon the same basal plan that is seen in all the hosts of later vertebrates. That is, their brain and nerve tubes were located on the upper or dorsal part; beneath this was a long elastic tube, the notochord, and beneath the latter a digestive tube. Thus they were profoundly different from worms, crustaceans, scorpions, and insects, in all of which the nerve tube is on the side next to the ground. These earliest chordates are called Ostracoderms, meaning "shell-skins," because their heads and chests are covered with a shell, or shield, composed of a hard skeletal substance related to dentine. As compared with later fishes, most of the Ostracoderms were probably rather sluggish, clinging to the rocks or resting on the bottom, sucking in small floating food particles by a pumping action of the throat. Their "jaws" were at most simple pincer knobs around the mouth, and they seem to have lacked the cartilaginous bars that form the jaws of Sharks. Hence they are often called Agnatha ("jawless").

In one order of Ostracoderms, the Heterostraci, typified by *Pteraspis* ("wing shield"), no bone cells were present in the shield, which was composed of five main plates. In the second order, Osteostraci, bone cells were well developed, the head shield was continuous, and the large eyes were on top of the head. In a third group, Thelodonti, the shield was represented by numerous small plates or denticles, and the fore part

"The Fossil Aquarium": a restoration of early fishes from the Old Red Sandstone of Cromarty, Scotland

Restorations by Dean, Hussakof, and Horter, partly after Traquair; background by C. R. Knight





of the body was rounded and flattened. In a fourth group, Anaspida, the general form was more typically fishlike, and a more active, almost predatory, life is indicated.

Some of the Ostracoderms have the characters that would be expected in the remote ancestors of the existing Lampreys and Hagfishes, or Raspmouths (see page 16), although the fossil connecting links have not yet been found. In the larval stage of the Lamprey, the arrangement of the mouth, brain, and gills is remarkably like that of the Ostracoderms.

The Fossil Aquarium

The "fossil aquarium" represents some of the leading fish types that flourished in the ages preceding the appearance of cold-blooded, land-living animals. All the fishes shown were found in a single locality and in a single layer of Old Red Sandstone (mid-Devonian). In their coloring, they have been made to correspond with their nearest living relatives.

The world of fishes as it was in Devonian times was already many millions of years old. Some of its older races, for example the Acanthodians (Nos. 3, 4, 6) and Arthrodires (No. 5), were already long past their prime. On the other hand, there were then comparatively young and rising groups, such as the Lobe-Fins (Nos. 1, 2) and Lungfishes (Nos. 8, 9), which were destined to become more numerous and diversified and then to dwindle toward extinction. Finally, there were the true Ganoids (No. 7), the ancestors and forerunners of the countless hosts of Teleost fishes, which for at least the past 80 million years have swarmed in all the seas and fresh waters of the earth.

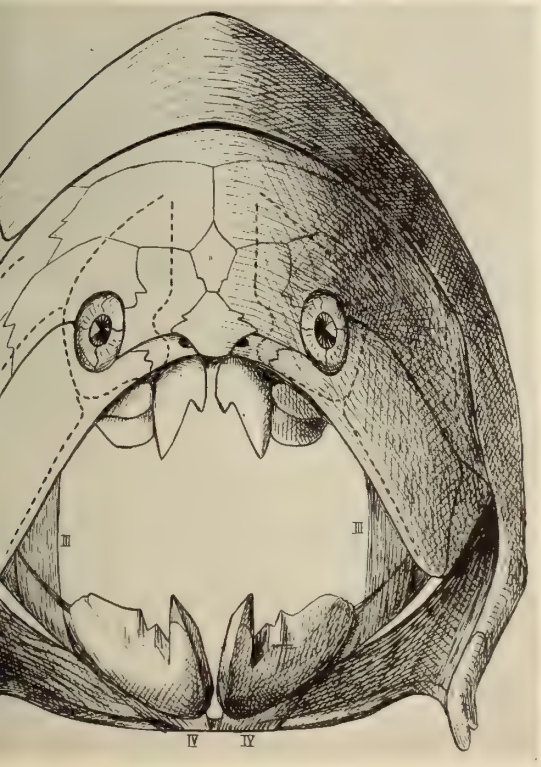
Arthrodira

(Placoderms in part)

In the Arthrodira, or Joint-Necked Fishes, the head, shoulders, and abdomen were armored with plates of bone; the jaws were

The head of a joint-necked fish: *Dinichthys terrelli* Newberry. he entire fish must have measured about 15 feet in length. Reconucted from many fragments of Cleveland shale in the collections the American Museum

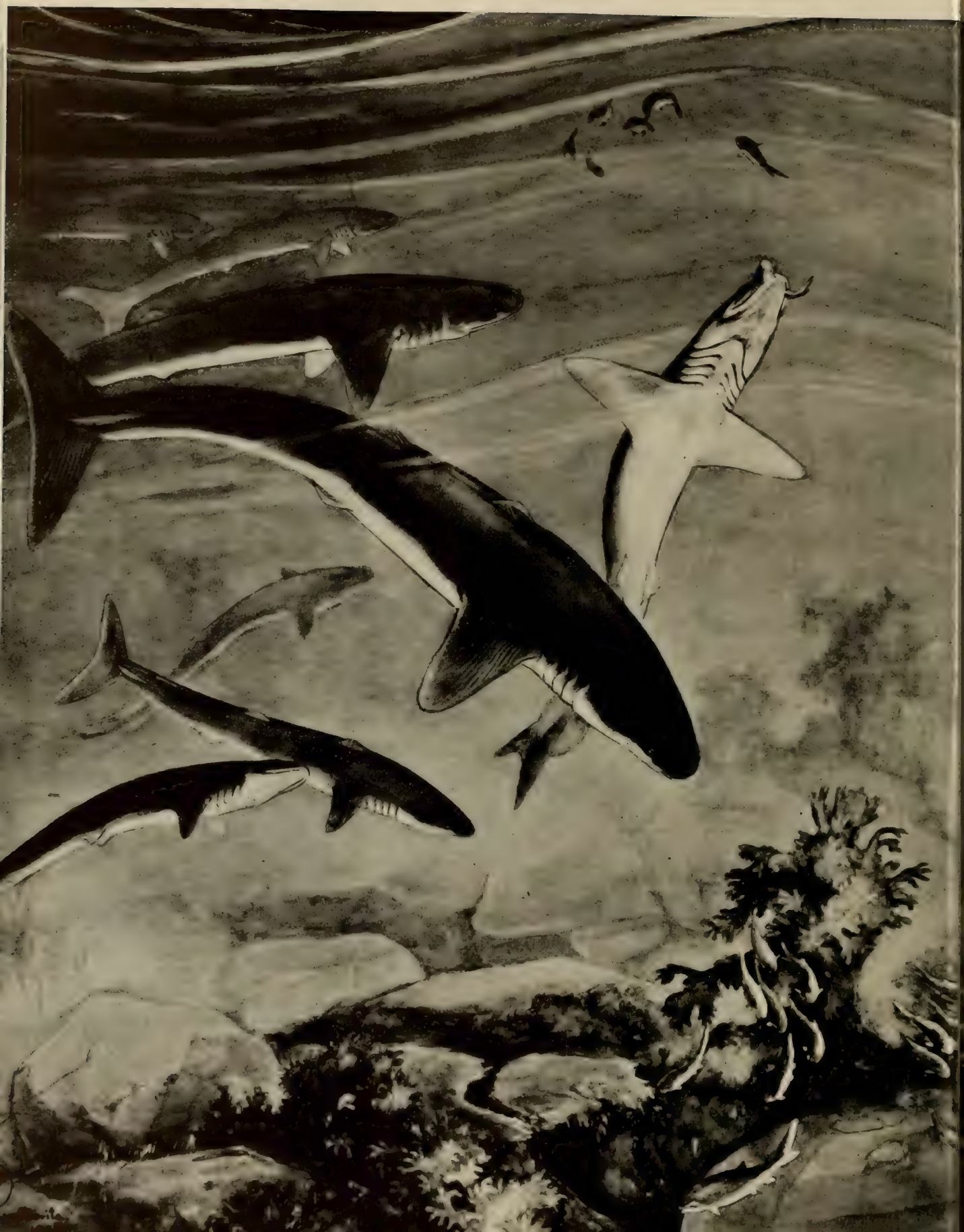
From original restoration and drawing by A. Heintz



Head and shoulder plates of another giant Arthrodire, *Titanichthys clarkii*. Its complete length was about 20 feet

A.M.N.H. photograph





provided with "teeth" or cutting plates. These fishes ranged from a few inches to 20 feet in length and lived abundantly in the seas and rivers of the Devonian period (275 to 340 million years ago), becoming extinct during the beginning of the Coal Period (Carboniferous). They are a specialized group of Placoderms, the first of the jaw-bearing fishes.

Probably assignable to the Arthrodires are the Ptyctodontidae, a family extinct since the Devonian and known chiefly by jaws and dental plates.

Sharks

Sharks also were among the early jaw-bearing fishes and their class has survived throughout all later geologic ages.

THE FIN-FOLD SHARK, *Cladoselache*: This Shark is so named because its pectoral and pelvic fins, as well as its dorsal and anal fins, were like stiff folds of skin, strengthened internally by tapering rods of cartilage. The illustration opposite shows typical specimens as they might have appeared in life, some 300 million years ago in the Upper Devonian of Ohio. *Cladoselache* was made famous by Bashford Dean, who used it effectively in defending the "fin-fold" theory of the origin of paired limbs, which was that the pectoral and pelvic fins arose in much the same way and were made out of the same materials as the median fins (dorsal, anal, caudal), in opposition to Gegenbaur's theory that the median and paired fins had come from very different sources—the median fins from a fin-fold, the paired fins from external gills.

EDESTIDAE: These are extinct Sharks which carried a great spiral of teeth lying in the mid-line of the lower jaw. They have been found in the Permian and Carboniferous rocks of Europe and North America (approximately 225 to 275 million years ago).

he ancient Fin-fold Shark,
***selache,* as it may have ap-**
l in life some 300 million years

n by Bashford Dean, painted by Kako Morita



The huge jaws of the giant prehistoric Shark *Carcharodon megalodon,* a fossil relative of our present-day Man-eater

A.M.N.H. photograph

GIANT FOSSIL SHARK, *Carcharodon megalodon:* About the time when the glaciers covered the northern part of North America, the seas were inhabited by gigantic Sharks. The actual teeth of one of these monsters, shown above, are exhibited in the American Museum, set in jaws modeled after those of the Man-eater Shark, which is the nearest living relative of the giant extinct species. The average height of the teeth is 4 1/4 inches. The estimated length of a *Carcharodon megalodon* with such teeth would be 46 feet.

Fossil teeth of Mackerel and Requiem Sharks and dental plates of Rays are still abundant in various localities, particularly North Carolina and the New Jersey marls.

Skates and Rays

These are essentially Sharks in which the pectoral fins have been greatly widened and the entire body flattened, as discussed previously. The existing Monkfish, *Squatina squatina* (see diagram, page 24) is a direct descendant and survivor of its ancestors of the Jurassic period. It is intermediate between the Sharks and the Rays.

Some of the fossil Rays developed great crushing and grinding plates not unlike those of the recent forms.

Silver Sharks
(CHIMAEROIDS)

Chimaeroids appeared in early geologic times and were most numerous and diversified during the Cretaceous, between 60 and 120 million years ago. They form a small group of fishes whose existing representatives with few exceptions inhabit the deep sea. Complete fossil Chimaeroids are rare. They are mainly known from detached plates and spines.

The fishes of this group are interesting to zoologists as survivors of an ancient stock more closely akin to primitive Sharks than to any other fishes. In general, the Chimaeroids retain sharklike features, but in a highly modified form. The head is typically rat-shaped, and the body tapers. The tail is wispy and the pectoral fins—the main organs of swimming—are large. The numerous surface denticles of the Shark have in large measure disappeared, and the many small teeth are represented usually by three pairs of dental plates. The intestinal valve is present. The upper jaw, instead of being separate from the skull, as in Sharks, is fused with it. The skeleton is cartilaginous, and the dorsal spines strong.

Lungfishes
(DIPNOANS)

The structures distinguishing the Dipnoans are (1) a lung, which may be single or double lobed; (2) teeth, which are crushing or cutting plates with radiating ridges; and (3) paired fins supported by a jointed rod of cartilage with similar or smaller rods branching from it on either side.

The recent Dipnoan representatives are the Lungfishes of Africa, Australia, and South America (see page 26). The most ancient fossil Lungfish is the Devonian form, *Dipterus*, well known by fossil remains from the Old Red Sandstone of Scotland. It had two separate dorsal fins, and the head was covered with numerous small, enamel-coated bones.

Lobe-fins
(CROSSOPTERYGIANS)

The oldest of this group from the Old Red Sandstone of Europe, were long-bodied fishes with voracious mouths. Their pectoral and pelvic fins however, were lobate or fringe-finned, that is, they had a more or less elongate bony and fleshy core surrounded on the front and rear borders by long, fringing, bony and dermal rays. The shorter, lobe-shaped fins resembled the paired limbs of amphibians in having only a single bone, representing the humerus or the femur respectively at the proximal end of each paddle or limb. These forms, the Rhipidistia, also approached the amphibians in skull structure and are believed to have stood close to the ancestral line of the latter. The Rhipidists have two dorsal fins and a peculiar type of tail. Among the modern fishes, two genera, *Polypterus* and *Erpetoichthys* of Africa, were formerly believed to be the direct descendants of the

Devonian Crossopterygians, but Professor E. S. Goodrich has shown that they differ from the latter in many important structural features and that they may rather have been derived from ancient Ganoids of the Palaeoniscoid type.

One branch of the Rhipidists gave rise to the Coelacanths, which dated from Devonian to Cretaceous times. All but one species of them became extinct in the Cretaceous period (at least 60 million years ago), but in 1938, *Latimeria*, a living survivor of this stock was taken off the coast of South Africa (see page 29).

Ganoids

The Ganoids comprise an extensive group of fishes, whose survivors include the Sturgeons, Garpikes, and Bowfins (see page 30). The fossil members of this group were numerous during the late Palaeozoic and early Mesozoic. The older forms had prominent enameled and bony scales and in many structural features are intermediate between the Sharks and the Teleosts. The specimens shown in the exhibit are mainly from the celebrated Jurassic lithographic stone in Solenhofen, Bavaria (about 120 to 155 million years old).

The Pycnodonts (*pycnos* = "crowded"; *odous* = "teeth") are extinct Ganoids with a deep compressed body, persistent notochord, and numerous small grinding teeth. They were abundant and widely distributed during the Mesozoic era, but gradually became extinct and disappeared in the early Tertiary. Some specimens reached a length of 3 feet.

Sea Tyrants of Ancient Kansas: Among the strange fishes that swarmed in the ancient seas of Kansas, none are more noteworthy than the Amioid *Protosphyraena*, the Saw-finned Fish. Its bony snout was prolonged like that of a Gar. There were two tusklike teeth in the upper jaw, and the sharp teeth of the lower jaw were like those of the living Barracuda. The front edge of the enormous pectoral fins was serrated, and it is supposed that the fish used these in attacking its enemies.

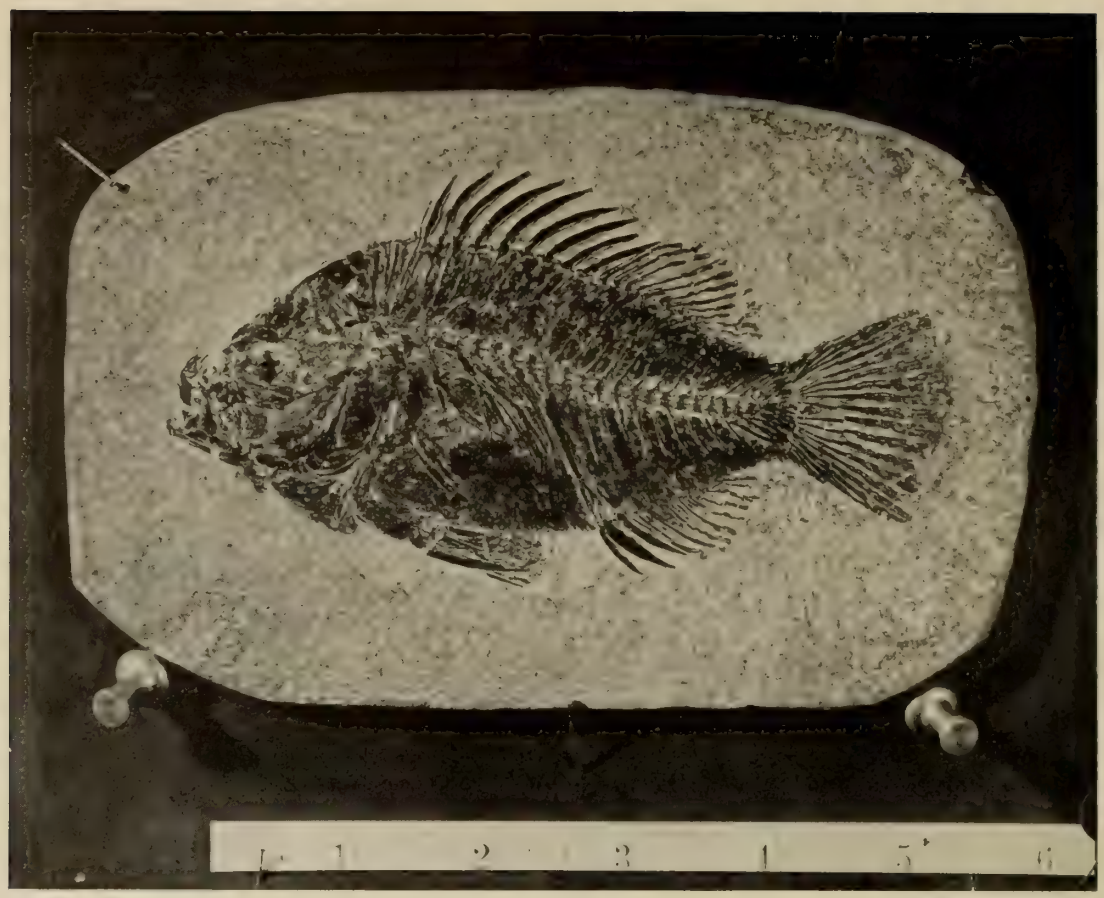
Teleosts
(Bony Fishes)

To this group, the Bony Fishes, belong the majority of food and game fishes of the world—the Bass, Carp, Cod, Eel, Herring, etc. They are the dominant type of fishes at the present time.

The Teleosts are exceedingly diverse in form, size, and anatomical structure, having become adapted to the most varied conditions in seas, lakes, and rivers. In typical Teleosts, the skeleton is bony or calcified, the fins are light and flexible, and the body is covered with thin, overlapping scales. The brain and sense organs are well developed, especially for sight and hearing.

These fishes are descended from, and have supplanted, the Ganoids. Many of their forms, including several orders, appeared between 60 and 120 million years ago, during the Chalk Period, the earliest being the Herrings (Clupeoids) and the Ten-Pounders (Elopidae). An interesting series of transition stages can be arranged, leading by almost imperceptible degrees from Ganoids to Teleosts.

The Giant Bulldog Fish, *Portheus molossus* Cope: a gigantic fossil Teleost occurring in the Cretaceous of Kansas. The specimen shown in the American Museum's exhibit measures 15 feet 8 inches in length. *Portheus* is remotely related to the existing Tarpon. Its nearest living relative is the tiny *Chirocentrus dorab* of the Indian Ocean.



A.M.N.H. photograph

↑ ***Priscacara* sp., a fossil Cichlid from the Green River Shales**

Fossil Teleosts are widely distributed. The majority of those on exhibit in the American Museum of Natural History are from the Green River shales of Wyoming. This geological formation consists of soft, buff-colored shales which appear to have been deposited in an estuary or in a land-locked bay during the Middle Eocene around 15 million years ago. The fishes found in these shales are of great variety and beautifully preserved. Those on exhibit formed part of the collection brought together by the distinguished palaeontologist Edwin Drinker Cope.

One of the beautiful fossil fish skeletons from the Green River shales at "Fossil Station," Colorado, adorns the living room or study in many homes in our country. Such specimens are frequently offered for sale as curiosities, but occasionally someone will bring in a specimen because he really wants to know how these long-extinct relatives of the Herrings, Sunfishes, and other existing families came to be preserved as fossils in such countless thousands in certain localities. Students of fossils bring their specimens to the Museum to compare them with ours, in order not only to determine the correct names for them but to learn more about the Green River fish fauna as

a whole, and if possible to find out why the descendants of some of these fishes may be found living today in the same general region, while the nearest existing relatives of others are so far away as Africa and South America.

The Green River fish fauna is only one of a long series of similar assemblages that have been found in rocks of the Tertiary, Cretaceous, and older ages ranging back for many millions of years. In the Bashford Dean Memorial collection may be seen a few samples of the fossil fish faunas of the following ages:

From the Upper Silurian and Lower Devonian periods: the Ostracoderms or oldest known forerunners of the fishes (see page 82).

From the Lower, Middle, and Upper Devonian periods: the ancestors of the Ganoids or early bony fishes and Lungfishes (pages 86 and 87), the ancestors of the Sharks, Skates, and Rays (pages 85 and 86). From the Triassic: early representatives of the Ganoid ancestors of the Sturgeons, Garpikes, and Bowfins (page 87).

From the Jurassic: the descendants of the earlier Ganoids (page 87) and some of the ancestors of the Teleosts or higher bony fishes (page 88).

From the Upper Cretaceous: representatives of the Bulldog Fish (page 88) and other extinct side branches of the higher bony fishes, together with the direct ancestors of such modern families as the Tarpons, fresh-water Sunfishes, Perches, Basses, Triggerfishes, Angelfishes, and many others (page 88).

From the Eocene and later divisions of the Tertiary period: extinct species of modern families.

Thus the study of fossil fishes, especially during the past century and a half, has revealed that there has been a succession of fish faunas, and has provided increasing materials for the history of the main divisions of fish life. In another direction the comparative study of the skeletons of fossil and recent fishes has greatly broadened our knowledge of the early stages in the evolution of the skull, vertebral column, pectoral and pelvic girdles and even of the limbs both of fishes and of their land-living descendants, the four-footed animals.



Drawn by Louise Nash from a specimen discovered by G. F. Sternberg

The Giant Bulldog Fish, *Portheus molossus*, a fossil fish 12 feet 8 inches long found in the Cretaceous Chalk of Kansas (Between 60 and 120 million years old)

Reference List

Bibliography

DEAN, BASHFORD. *A bibliography of fishes.* New York: Amer. Mus. Nat. Hist., 1916-1923. 3 vols. Pp. x + 707.

General

BRIDGE, T. W., and G. A. BOULENGER. Fishes. In *Cambridge Natural History.* London: Macmillan Co., 1910. Vol. 7, pp. 141-727, figs. 91-440.

CURTIS, B. *The life story of the fish.* New York: D. Appleton-Century Co., 1938. Pp. xiv + 260, figs. 1-34, pls. 1-2, diagrs. 1-14.

CUVIER, G., and A. VALENCIENNES. *Histoire Naturelle des Poissons.* Paris, 1828-1849. 22 vols., pls. 1-650.

DEAN, BASHFORD. *Fishes, living and fossil;* an outline of their forms and probable relationships. New York: Macmillan Co., 1895. Pp. xiv + 300, figs. 1-344.

JORDAN, D. S. *Fishes.* New York: D. Appleton and Co., 1925. Pp. xv + 773, figs. 1-673, col. pls. 1-18.

NORMAN, J. R. *A history of fishes.* New York: Frederick A. Stokes Co., 1931. Pp. xv + 463, figs. 1-147, pls. 1-8.

REGAN, C. TATE. *Fishes.* In *Encyclopaedia Britannica,* 1944. Vol. 9, pp. 304-328, 2 pls.

ROULE, L. *Fishes and their ways of life.* [trans.] New York: W. W. Norton and Co., 1935. Pp. viii + 312, figs. 1-52.

Regional

BARNARD, K. H. *A monograph of the marine fishes of South Africa.* Ann. South African Mus., 1925-1927. Vol. 21, Pp. 1065, pls. 1-37.

BEEBE, W., and J. TEE-VAN. *Field book of the shore fishes of Bermuda.* New York: G. P. Putnam's Sons, 1933. Pp. ix + 377, figs. 1-300, 24 pls.

BIGELOW, H. B., and W. W. WELSH. *Fishes of the Gulf of Maine.* Bull. U. S. Bur. Fish., 1925. Vol. 40, pt. 1, pp. 567, figs. 1-278.

BOULENGER, G. A. *Catalogue of the fresh-water fishes of Africa in the British Museum.* London, 1909-1916. 4 vols., 1208 figs.

BREDER, C. M., JR. *Field book of the marine fishes of the Atlantic coast from Labrador to Texas.* New York: G. P. Putnam's Sons, 1929. Pp. xxxvii + 332, figs. 1-403, col. pls. 1-8.

DAY, F. *The fishes of India;* being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon. London, 1875-1878. 2 vols., pp. 778, pls. 1-198.

EIGENMANN, C. H. *The fresh-water fishes of British Guiana,* including a study of the ecological grouping of species, and the relation of the fauna of the plateau to that of the lowlands. Mem. Carnegie Mus., 1912. Vol. 5, pp. 578, pls. 1-103.

EVERMANN, B. W., and M. C. MARSH. *The fishes of Puerto Rico.* Bull. U. S. Fish Comm., 1900. Vol. 20, pt. 1, pp. 51-350, figs. 1-112, pls. 1-52.

FOWLER, H. W. *The marine fishes of West Africa based on the collection of the American Museum Congo Expedition, 1909-1915.* Bull. Amer. Mus. Nat. Hist., 1936. Vol. 70, 2 pts., pp. 1493, figs. 1-567, 1 col. pl.

Contributions to the biology of the Philippine Archipelago and adjacent regions. Bull. U. S. Natl. Mus., 1941. Vol. 13, no. 100, pp. x + 880, figs. 1-30.

GILBERT, C. H., and E. C. STARKS. *The fishes of Panama Bay.* Mem. California Acad. Sci., 1904. Vol. 4, pp. 304, pls. 1-33.

HUBBS, C. L., and K. F. LAGLER. *Guide to the fishes of the Great Lakes and tributary waters.* Cranbrook Inst. Sci., 1941. Bull. no. 18, pp. 100, figs. 1-118.

JENKINS, J. T. *The fishes of the British Isles.* London: Frederick Warne and Co.,

1925. Pp. vii + 376, pls. 1-142.

Jordan, D. S., and B. W. Evermann. *Fishes of North and Middle America.* Bull. U. S. Natl. Mus., 1896-1900. Vol. 47, 4 pts., pp. 3313, pls. 1-392.

The aquatic resources of the Hawaiian Islands. I. The shore fishes. Bull. U. S. Fish Comm., 1903. Vol. 23, pt. 1, pp. 574, figs. 1-229, pls. 1-138.

McCulloch, A. R. *The fishes of New South Wales.* Australian Zool. Handb., 1922. No. 1, pp. xxiv + 104, pls. 1-43.

Nichols, John T. *The fresh-water fishes of China.* New York: Amer. Mus. Nat. Hist., 1943. Natural History of Central Asia, vol. 9, pp. xxxvi + 322, figs. 1-143, pls. 1-10, 1 map.

Nichols, J. T., and C. M. Breder, Jr. *The marine fishes of New York and southern New England.* Zoologica, 1927. Vol. 9, pp. 192, figs. 1-263.

Roughley, T. C. *Wonders of the Great Barrier Reef.* Sydney: Angus and Robertson Ltd., 1936. Pp. xvi + 282, pls. 1-52.

Schrenkeisen, Ray. *Field book of fresh-water fishes of North America north of Mexico.* New York: G. P. Putnam's Sons, 1938. Pp. xii + 312, 1 col. pl.

Waite, E. R. *The fishes of South Australia.* Adelaide, 1923. Handb. Fauna Flora South Australia, pp. 243, illus.

Special Groups

Eigenmann, C. H. *The American Characidae.* Parts I-IV. Mem. Mus. Comp. Zool., 1917-1927. Vol. 43, pp. 428, pls. 1-90.

Garman, S. *The Plagiostomia* (sharks, skates, and rays). Mem. Mus. Comp. Zool., 1913. Vol. 36, pp. 528, pls. 1-77.

White, E. G. *Interrelationships of the Elasmobranchs with a key to the order Galea.* Bull. Amer. Mus. Nat. Hist., 1937. Vol. 74, pp. 25-138, figs. 1-66, pls. 1-55.

Whitley, Gilbert P. *The fishes of Australia.* Pt. 1. The sharks, rays, devil-fish, and other primitive fishes of Australia and New Zealand. Sydney, Austral., 1940. Zool. Handb., pp. 280, figs. 1-303.

Skeleton

Gregory, W. K. *Fish skulls: a study of the evolution of natural mechanisms.* Trans. Amer. Phil. Soc., 1933. Vol. 23, art. 2, pp. i-vii, 75-481, figs. 1-302, pls. 1-2.

Game Fishes

Caine, L. S. *Game fishes of the South and how to catch them.* Boston: Houghton Mifflin Co., 1935. Pp. viii + 259, illus.

Farrington, S. K., Jr. *Atlantic game fishing.* New York: Kennedy Bros. Inc., 1937. Pp. xii + 298, 139 pls.

Pacific game fishing. New York: Coward-McCann, 1942. Pp. xii + 290, illus.

Heilner, Van Campen. *Salt water fishing.* Philadelphia: Penn Publishing Co., 1937. Pp. 452, 12 col. pls.

Jordan, D. S. and B. W. Evermann. *American food and game fishes.* New York: Doubleday, Doran and Co., 1920. Pp. 573, figs. pls.

LaMonte, F. *North American game fishes.* Doubleday, Doran and Co., 1945. Pp. 202, pls. and col. pls. 1-73.

Walford, L. *Handbook of common commercial and game fishes of California.* Fish & Game Div. California, Fish Bull. 28, 1931. Pp. 177, figs. 1-137.

Marine game fishes of the Pacific coast from Alaska to the equator. Berkeley: Univ. California Press, 1937. Pp. xxix + 203, figs. 1-25, pls. 1-69.

Aquarium Fishes

Coates, C. W. *Tropical fishes.* New York: Liveright, 1933. Pp. xi + 226, 28 pls. & col. pls.

Innes, W. *Exotic aquarium fishes.* Philadelphia: Innes Publishing Co., 1945. Pp. 507. pls. and col. pls.

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Peoples of the
PACIFIC

By HARRY L. SHAPIRO



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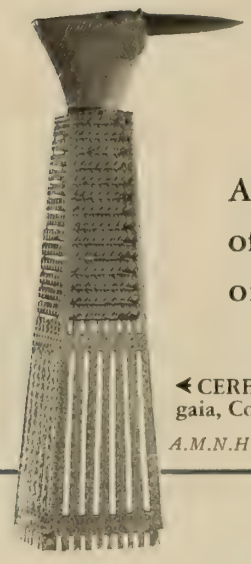
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Peoples of the PACIFIC



By HARRY L. SHAPIRO

Chairman and Curator of Physical Anthropology, American Museum of Natural History

An introduction to the island natives of a vast region that has become of interest to every American

◀ CEREMONIAL ADZE from Mangaia, Cook Islands, in Central Polynesia

A.M.N.H. photograph

NEVER before in our history has our attention been so firmly focused on the Pacific. The intensity of our interest is natural when so much in our national and personal destinies is being determined there. Those of us who have dear ones fighting in the Pacific are, of course, especially eager to reconstruct imaginatively the kind of lives they are leading, to share, if only vicariously, in their experiences and to learn something of the people they will be meeting. To help you do this I shall try to tell you something of these people of the Pacific and their manners of living.

The problem of doing this adequately in a few pages is stupendous. It is like asking someone to describe in ten minutes all the varieties of race and custom to be found in the Western Hemisphere. I think you will better appreciate why it is so difficult a task when I refresh your memory of



▶ THE MULTITUDE OF ISLANDS in the Pacific are divided for convenience into a number of island assemblages. The grouping is based upon geography and population. Some of the distinctions are arbitrary but traditional

the vastness of the Pacific and the diversity of its people.

From north to south the Pacific is about 8350 nautical miles in distance. Its greatest width covers an even vaster distance. From Panama to the Philippines the distance is about 9300 nautical miles, or roughly three times the distance from New York to San Francisco. In this area which is greater than all the land area of the world put together, there are thousands on thousands of islands, some in thickly clustered groups or archipelagoes, others isolated and solitary—hundreds of miles from another speck of land. They range from huge islands that are continents or subcontinents like Australia and New Guinea to tiny coral reefs hardly rising above the surge of the sea. Some are rich in vegetation—actually jungles—, others are dry, desolate, and barren. On most of these islands native people may be found in



indonesia

a wide variety of types and living in cultures that run from the simplest forms to highly elaborate and complex civilizations—either native or European or Chinese.

Under the circumstances there is space only for a few important generalizations and a few characterizations.

You will notice that on the adjacent map of the Pacific between the Malay Peninsula and Australia lie a large number of islands large and small, closely studded and giving the appearance of a huge causeway connecting the Asiatic mainland and Australia. These, with the exception of New Guinea, constitute the East Indies. The Philippines, although not in a direct line, are essentially part of this island pathway, lying a little to the north and paralleling the Indo-China coast.

From this chain of close-set islands two separate branches emerge. The northern one, stretching eastward on the level of the Philippines, is known as Micronesia and includes the Carolines, the Gilberts, and the Marshalls. The southern line begins as an extension of New Guinea and leads in a southeasterly direction. These are the Melanesian islands, through which our troops have been forging their way recently.

To the eastward the Micronesian and Melanesian lines converge and open into the Central Pacific, into a region of far flung and scattered islands known as Polynesia. These are the classic and romantic islands of the South Seas, the scenes of Herman Melville, of Stevenson, of Nordhoff and Hall, and of *White Shadows*. New Zealand, which lies southeast of Australia and is isolated from the rest of Polynesia, is included therein because of the historical accident of its settlement by Polynesians. Hawaii, similarly separated from the central Polynesian area, lies to the north and belongs to Polynesia because its inhabitants were of the same origin.

Each of these geographic areas is characterized by people of different and distinctive racial origin and diverse cultures. Even within these large groups, minor local variations exist which make it difficult in certain respects to be dogmatic about the entire



Photo by courtesy of Claire Holt

▲ THE DOMINANT PEOPLE of modern Indonesia are the Malays. Physically, their Mongoloid affinity accounts for their resemblance to Chinese and Filipinos, among whom similar or related types are found. This is a chief from a district in the northern coast of Sumatra



MacMillan photograph

▲ THE BROAD NOSE, heavy brows, and keel-shaped skull of this patriarch of the Arunta tribe are typical of Australian aborigines, who represent an early stage in human evolution

australia

great distances. Consequently, they must have been difficult to discover and settle, requiring a high degree of maritime skill and a substantial development of seaworthy crafts. They would not be likely to be populated by people on a low level of culture. In fact, both Micronesia and Polynesia were settled late in Pacific history—Polynesia not until after the birth of Christ. New Zealand, for example, was reached by Polynesian navigators only as late as 1300 A.D. It is frequently assumed that the Polynesians ventured as far as they did largely because the intervening islands were already occupied, causing them to continue their search for uninhabited islands into the broad seas where less skillful seamen did not dare to venture.

The Polynesians are a tall, well-built handsome people. In skin color they range from a light brown to a complexion only slightly darker than that of a brunette white. Their hair is straight or wavy and is carefully groomed by the women, who wear it long and scented with coconut oil.

region. It is important, however, to keep in mind the geographic relationships of these island areas since they explain the distribution of the various races to be found in this part of the Pacific. In the first place, they all connect up with southeast Asia, particularly the Malay Peninsula. It is almost as if the Malay Peninsula were like a funnel through which people have passed into the islands beyond, spreading out as they moved away. But on the eastern extension of these islands they fall short of America by two or three thousand miles. We have every reason to believe that all these islands have been settled by migrants from Asia in a number of distinct waves at diverse epochs in man's history. Any connection with America if it ever existed was of minor significance.

Next, you will notice that the islands of Micronesia and Polynesia are small and widely scattered over



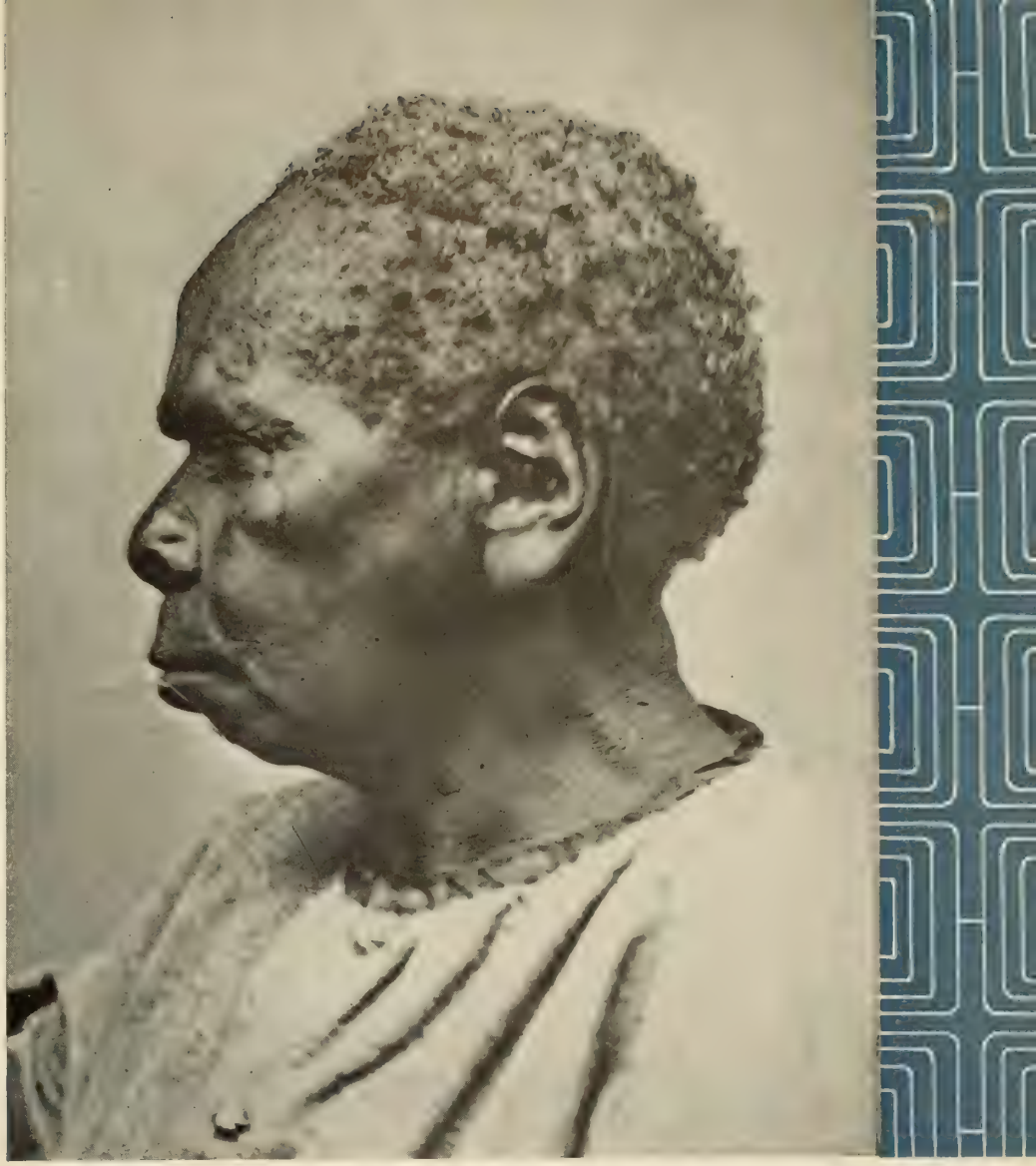
▼ AUSTRALIA was settled by an early migration, probably from Java, where a primitive human type similar to the Australian aborigine is known to have existed

Their lips are moderately full, and their noses are on the thick side but not flat. They are distinctive and easily recognized among the other islanders of the Pacific, so that by definition the islands they inhabit are known as Polynesia, regardless of distances and geographic differences. These islands extend from Hawaii on the north to New Zealand on the south and from Samoa and Tonga on the west to the Marquesas and Easter Island on the east. Most of the romantic ideas about the South Sea islanders cluster around these people. I have spent a considerable amount of time with them. I have lived and sailed with them for days and months. They are hospitable, kindly, sympathetic, and intelligent. Any American who knows them well finds their racial difference no barrier whatever to close and satisfactory friendship. They appreciate kindness and more than re-



turn in their own way any service you render them. On one island where I had been doing some scientific work I had occasion to nurse a young man who had been suffering from a severe infection. Fortunately I was able to help him from my store of medical supplies. His family was so grateful that for some months, in fact during my entire stay on the island, they brought to my door each day an ample supply of drinking coconuts and fresh fish whenever it was available. They wept on my departure and on revisiting them four years later I was greeted as an intimate member of the family.

The culture of the Polynesians as it used to be has now disappeared from most of the islands. The influence of European and American visitors was profound and rapid. Missionaries replaced the ancient rites by Christianity. Traders brought in tools, cloth, and various manufactures, causing the traditional crafts to languish and die. Nevertheless, much of the old customs still survives away from the ports, and to the discerning eye and the inquiring mind a rich heritage of former days may be revealed.



Beattie Studios photograph, Hobart

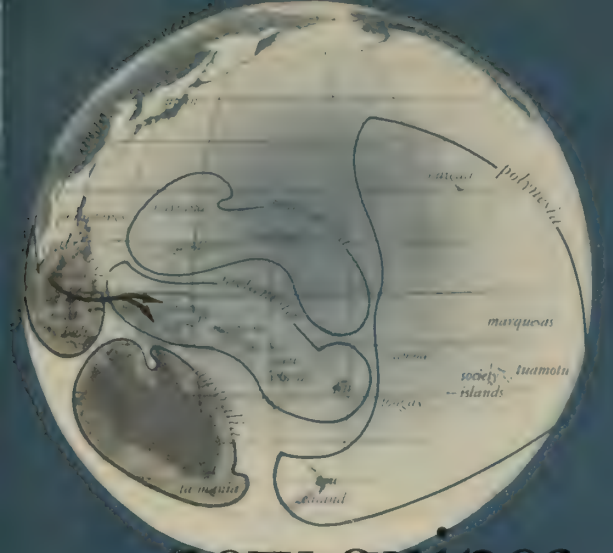
▲ The natives of Tasmania, now extinct, differed from Australians particularly in hair form. They are sometimes considered to be an early and isolated form of Melanesian. The last of the Tasmanians died in the 1870's

Two of the most obvious elements of native life in Polynesia are coconuts and fish. Polynesians are great fishermen, and much of their diet comes from the sea. They were so adept at fishing that they have retained almost unchanged their fishing gear. Nothing we could offer was as good for the purpose. The coconut tree enters deeply into the economy of the Polynesian, as it does elsewhere in the Pacific. From the dried meat of the nut they make copra—their most important cash crop. From the fiber they make cord; from the fronds of the tree they weave baskets, sun shades. Their houses are sided with coconut leaves. The shell of the nut is used for containers. They drink the water of the nut and eat the meat at various stages of ripeness.

The Polynesians had in former days a very rich and poetic oral literature, made up of religious chants, legends, creation stories, and mythology. Some of this still survives. But almost nothing remains of their elaborate social organization. The hereditary chiefs are gone. The great religious structures are now dilapidated and overgrown—sad reminders of a vanished state.

Moving westward toward Asia we traverse three distinct cultural areas —Micronesia on the north, New Guinea and Melanesia to the south, with Australia just beyond Melanesia. Australia is the home of one of the most primitive races of man now living. This is the Australian aborigine, now largely confined to the central desert. Just south of Australia is Tasmania, where another primitive type of man existed but is now extinct, having been exterminated by the 1870's as the result of the contact and encroachment of English settlers.

The Australian aborigine, numbering some 10,000 individuals, is primitive physically, with a narrow shelving



new guinea

▼ THE NATIVES OF NEW GUINEA present a wide variety of types. The one below at left is from Mt. Hagen, a little known district in the interior of central New Guinea

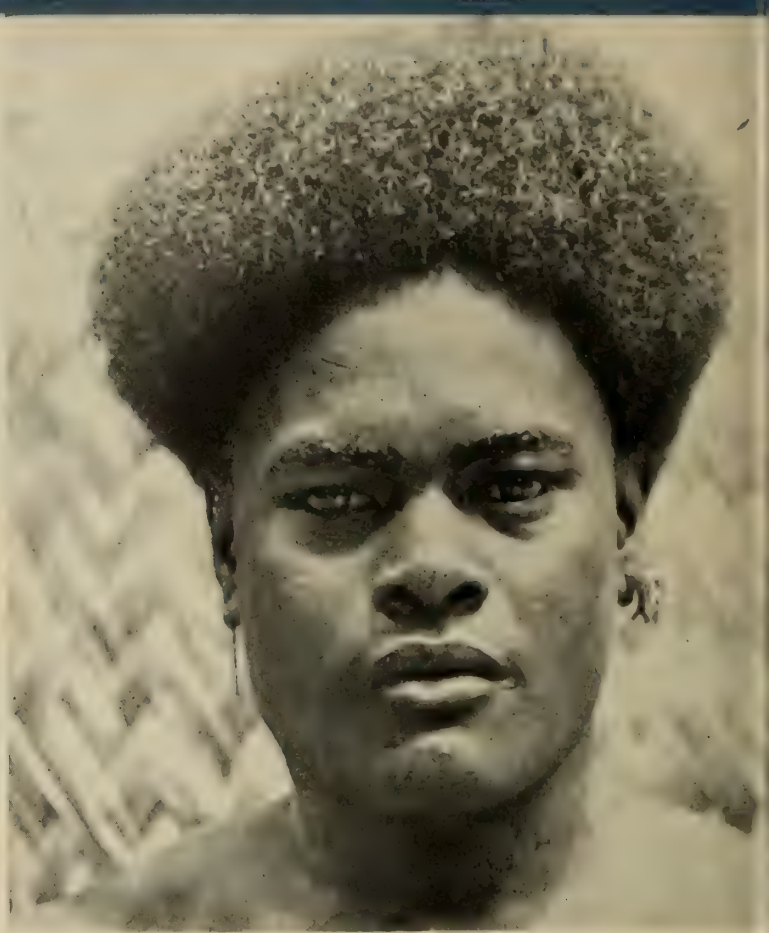
▼ MELANESIANS are sometimes classified as Oceanic Negroes. This Solomon Island man with his mop of fuzzy hair is representative. Melanesian Islanders are frequently employed on large plantations run by Europeans. In the old days they were impressed into service against their will by "black birders"



melanesia



Photo courtesy of M. J. Leahy

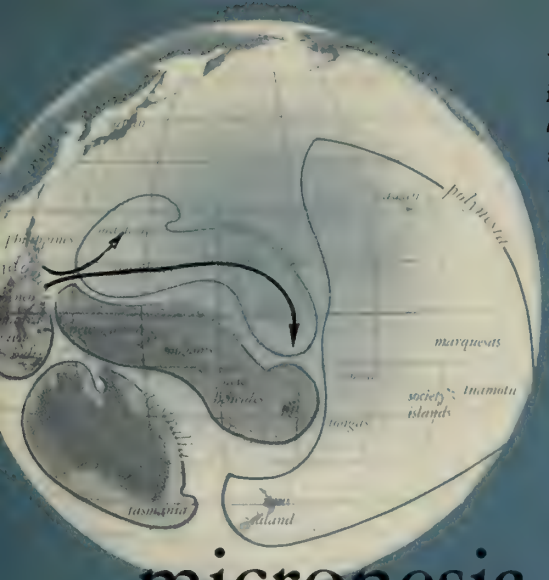


Photograph by H. Ian Hogbin

brow and strongly projecting face. He is almost black in color and has wavy hair abundant on head and body. His equipment of tools and gear is simple and restricted, although he has the remarkable boomerang. His life is harsh and precarious. Clothing is scant or absent, and shelter is at a minimum. He is, however, noteworthy among anthropologists by virtue of his highly complicated kinship system regulating marriage and his reputed ignorance of the facts of life, at least some of them. The role of the father in reproduction is not understood by these people.

The Melanesians and the natives of New Guinea may be grouped together in spite of distinctions which are commonly drawn among them. They are a dark brown people, usually having frizzy hair, broad flattish noses, and protruding faces. They are sometimes called Oceanic negroids because of their resemblance to African Negroes. Pygmy people of unknown origin live in the interior of New Guinea and the New Hebrides. These are the people whom our soldiers are meeting now in the Solomons, in New Britain, and New Guinea. By our esthetic standards of physical beauty they fall far below the Polynesian, although many of them are strong and robust.

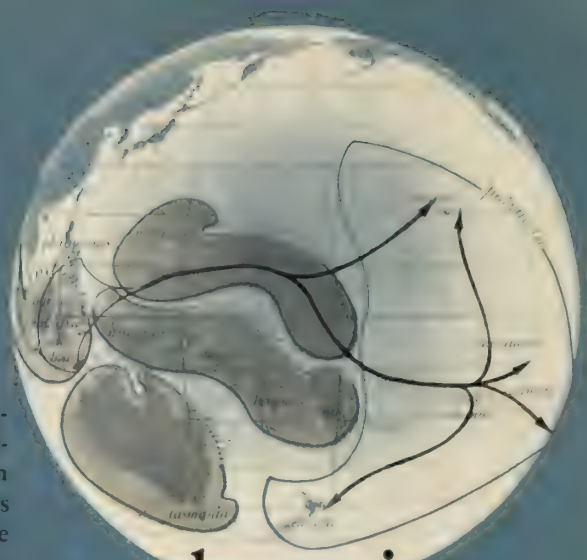
The Melanesians as well as the Australian aborigines were not as highly developed in the nautical arts as the Polynesians, which accounts for their inability to move beyond their present island homes. To reach these islands, no great skill was required, since they are large, high islands, often within easy reach of each other. Thus even with primitive means of navigation the natives could reach their present settlements. They probably represent an early migration from more westerly islands, moving eastward under pressure of invading forces.



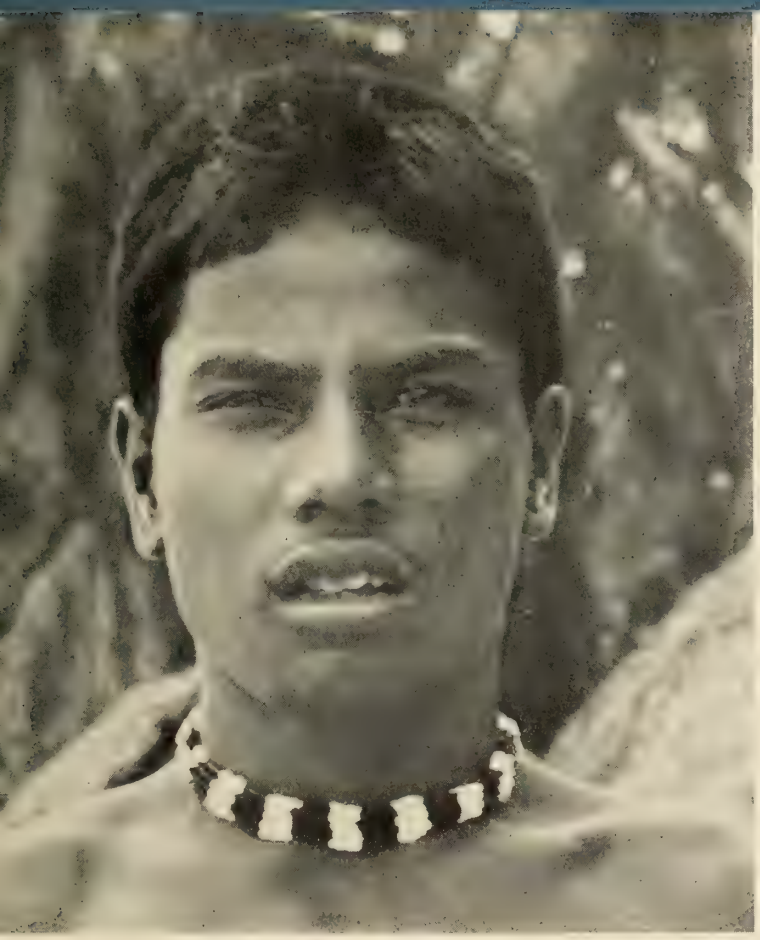
micronesia

▼ THIS NATIVE of the Gilberts in eastern Micronesia *(lower left)* is quite unlike the characteristic type of the western Micronesia population, where Malay influence has infiltrated

▼ POLYNESIANS are the latest comers into Oceania and have migrated farther into the Pacific than any other people. The Marquesas Islands, the home of this man, lie on the easternmost limit of Polynesia. The maps in this panel show the successive migrations



polynesia



Photograph by Albert G. Mayer, A.M.N.H.



Photograph by Harry L. Shapiro

Melanesian culture and language are highly variable. Students have found profound differences within short distances. These circumstances make it difficult to generalize for the whole group. Nevertheless, certain common features do occur widely in this area. A noteworthy decorative skill is especially interesting. It expresses itself on some islands in wood carving, on others in ritual objects and masks of intricate color and bold design. These ritual paraphernalia are associated with highly organized secret societies in which the entire community is involved. Indeed, secret societies seem to have run rampant. The technique of the personal build-up also reaches unusual levels here in Melanesia. To acquire prestige some groups go in for complicated systems of giving away valuable objects, others by piling up mountains of food for huge feasts. The extreme development of the aristocratic and caste system formerly characteristic of Polynesia seems never to have evolved here.

Melanesian houses are generally simple one-room affairs, a cover of thatch over a light frame. Frequently the houses are raised on stilts, which makes a convenient dumping ground available just under the floor. The pigs, which are ubiquitous, make good scavengers and keep the villages fairly clean. Many of these villages have a much larger building elaborately decorated for use as a kind of men's club, forbidden to the women, and as sleeping quarters for adolescent boys.

Gardening is a more frequent occupation here than in Polynesia. Gardens are an important source of food. The forest is slashed and burnt by the men, and the women take over, using a hoe culture. Some of the more important food crops include the leaves and starchy rootstocks of the taro, sweet



▲ FISHING is one of the mainstays of Polynesian life

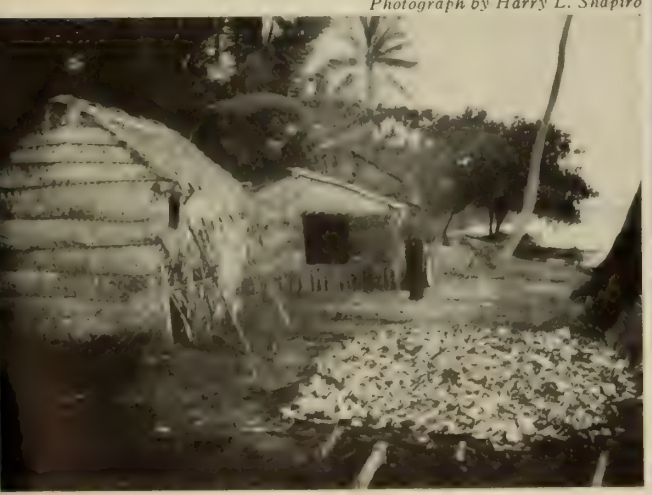
▼ MARQUESAN NATIVES cutting up a manta on the beach

Photograph by R. H. Beck, Whitney South Sea Expedition



▼ THE MEAT of the coconut, only cash crop of Polynesia's coral atolls, is dried and sold to traders

Photograph by Harry L. Shapiro



▼ TUAMOTUAN natives used to transport soil from Tahiti to make beds such as this for growing taro

Photograph by Harry L. Shapiro





Photograph by Harry L. Shapiro

▲ THE CLEAN CORAL sand makes excellent village streets. This village in the Tuamotus is like many others—coconut trees and sand. Modern houses are built of planks and roofed with tin

▼ FISHING is one of the arts of Polynesian life. Lines, nets, and traps were used. Most of the old fishing gear has survived European influence



polynesia



➤ ONLY IN THE REMOTE DISTRICTS do the older thatch roofed houses survive. This one is the home of the chief of Rapa. The thatch is commonly made of pandanus leaves, folded over the midrib of a coconut leaf

hotograph by R. H. Beck, Whitney South Sea Expedition

Photograph by R. H. Beck, Whitney South Sea Expedition



➤ THESE RAPA GIRLS are paddling home from the taro fields which are some distance from the village. Taro is an important food plant throughout Oceania. Fermented taro makes one form of poi—a widespread native dish

➤ THESE NATIVES OF RAPA gather on the jetty to welcome or to speed their guests. The isolation of the island lends a special festivity and excitement to the arrival of any visitors

Photograph by R. H. Beck, Whitney South Sea Expedition



australia



Photograph by Spencer

➤ AUSTRALIAN ABORIGINES are largely confined at present to central and northern Australia. Their number is estimated at around 10,000. This Kaitish man has a typical hair-do and a slit nasal septum for holding ornaments

➤ THE POVERTY AND SIMPLICITY of Australian life is suggested in this picture of an Arunta woman and child. Clothing is scanty or absent, equipment simple, and shelter at a minimum

➤ ALTHOUGH THE MATERIAL ASPECTS of aboriginal life in Australia are severe and primitive, their social and ceremonial life have some highly evolved elements. The ceremonial episode below depicts a thalaualla (black snake) drawing on the ground, with participants in full regalia. Some of the men are wearing elaborate head dresses. Their torsos are covered with feathers stuck to the body with human blood. The celebrants belong to the Warramunga tribe



potatoes, yams, pumpkins, squashes, bananas. Pigs and small game furnish most of the flesh foods.

Speaking of food reminds me that some of the Melanesians are notorious for their addiction to human sources of meat. Cannibalism until quite recently was not unusual in some of these islands. When I was on Norfolk Island in 1923 we received reports of the murder of several missionaries in the New Hebrides who were eaten by the native tribesmen. Although this vicious practice had been associated only with the Melanesians, it formerly was more widely spread and was known to occur even in Polynesia. On a visit in 1929 to the Marquesas in eastern Polynesia I met one old man who told me that as the son of the chief he was entitled to a finger of the victim, a morsel which he recalled as tasting quite good. Within



➤ THIS GROUP of old men were in charge of a tribal gathering held at Alice Springs. Each of them is the head of a totemic group. The shelter is constructed of boughs









Photos courtesy of Capt. Frank Hurley

▲ A NATIVE of New Guinea. Decorations and hair-do vary from tribe to tribe

▲ THE MEN'S CLUB HOUSE: usually an impressive part of Melanesian and New Guinea villages

▲ THE LOVE OF FINERY is universal. These native girls are adorned with flowers, seed necklaces, and shell ornaments



◀ A MANUS CHIEF paddling his outrigger canoe. Manus is one of the Admiralty Islands recently captured by our forces in the Southwest Pacific. The native village on Manus is built on piles standing in a lagoon

Photograph by R. H. Beck, Whitney South Sea Expedition

melanesia



◀ IN THIS ROW of boathouses are lodged the large canoes drawn up on the beach. The canoes are seaworthy enough for long voyages and are characteristic only of a limited part of the Papuan Coast of New Guinea

Photo courtesy of Capt. Frank Hurley



Photo courtesy of M. J. Leahy

▲ THIS VILLAGE, set among the mountains of the interior of New Guinea, was only recently discovered. It is an unspoiled example of native life, untouched by European influence



Photo courtesy of M. J. Leahy

➤ THE RARITY of a European spoon in central New Guinea endows this lowly utilitarian object with the glamour of a jewel. The beard is apparently dense enough to hold the spoon

▼ THE MINT on Malaita, in the Solomons. Shells cut into discs and strung on fibers constitute money for these Melanesians. The process of manufacture is long and laborious



the past decade, however, cannibalism has disappeared even in the remote islands of Melanesia.

Micronesia, which lies to the north of New Guinea and the Melanesian islands, includes the Marianas or Ladrones, the Palaus, the Carolines, the Marshalls, and the Gilberts. These groups begin to the east of the Philippines and continue along the tenth degree of latitude north of the equator, dipping south at the Gilberts toward Melanesia and Polynesia. Less is known about the people of these islands than about the Polynesians and Melanesians. During the Japanese mandateship, visitors and scientists were rigorously excluded for reasons which are well known to us now.

Physically the Gilbert and Marshall islanders approach the Polynesians in appearance, and much of their culture has similar relationships. But the material poverty of their low coral islets has inhibited the development or maintenance of a rich culture. The Gilbertese used to be famous for their armor woven from coconut fiber and their weapons studded with shark's teeth. A high degree of maritime skill was also characteristic.

As one moves westward toward the Asiatic mainland and the islands of the East Indies, the physical type becomes progressively more like the Malay until in the Palaus, Marianas, or in the western Carolines the Malay infiltration is very marked. The influence is by no means confined to racial characters. Many Malay cultural elements have also greatly affected western Micronesia, yet are absent farther east. For example, the chewing of betel nut is common in western Micronesia but is unknown in the east.

The East Indies are commonly typified in our minds by huge islands such as Java, Sumatra, and Borneo. But there are many more than these few imposing islands. From Sumatra, hugging the west coast of the Malay Peninsula, to the eastern islands off the shore of New Guinea is a distance of over 3000 miles. Within these limits lie thousands of islands, mostly of volcanic origin. Here live 70 million people, over half on the island of Java alone. The Philippines, just north of Central Indonesia and adjoining Borneo, are sometimes considered apart from the East Indies. Their cultural and racial affiliations with Indonesia, however, are so intimate that aside from geographic reasons they should be linked with the East Indies.

micronesia



Photo by C. H. Townsend

▲ THE GILBERT ISLANDERS were famous for their armor, woven from heavy coconut fiber. This warrior carries a shark-tooth weapon and wears a helmet made from the dried skin of the blowfish

▼ THIS SCENE in the lagoon of Truk shows the local variety of outrigger canoe. Such craft are speedy and require skill in handling

Photograph by Albert A. Mayer, A.M.N.H.



indonesia

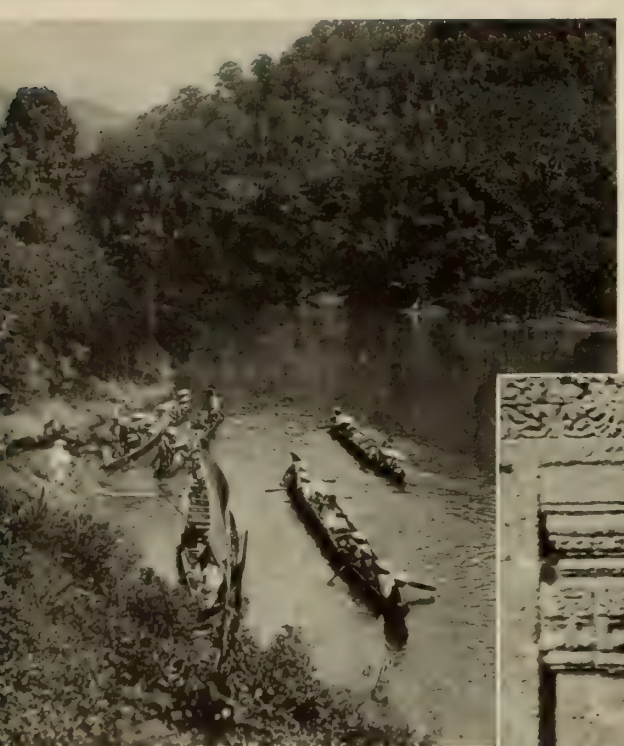


Photo courtesy of Carl Lumholtz

◀ SCENE ON THE KAYAN RIVER of Northern Dutch Borneo. The large Indonesian islands are almost continental compared with the small islands of Polynesia and Micronesia. As a result, Indonesian life is less restricted to a shore line occupation

▼ THE CULTURE OF INDONESIA reached high levels in pre-European times. Java was once a powerful kingdom with a complex civilization derivative in part from India. This relief cut in stone is part of the famous temple at Borobadur in Java

Photo courtesy of Claire Holt

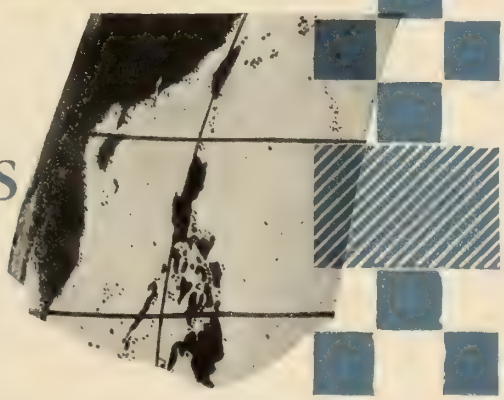




Photo by Jessie Tarbox Beals

MANY OF THE FILIPINOS are Malay in ori-
in, although traces of other races have sur-
ived. These Bagabo warriors are representa-
ve of the prevailing Malayan strain

philippines



THOUSANDS OF MILES of stone retaining
alls are required for the construction of
ese terraced hills, one of the most remark-
ble engineering structures in the Philippines

urtesy of Bureau of Insular Affairs, War Department, Washington



The people at present dominant in the East Indies are the Malays, who constitute a branch of the Mongoloid group of mankind. They are short, often muscular, with straight black hair, brown skin, a broad flattish face, full, somewhat bulbous brow, and moderately thick lips. The Javanese are of this type. The highest developments of native culture are generally associated with the Malays.

An earlier invasion of Malay people sometimes called Proto-Malays with less obvious Mongoloid traits is now represented by people living in the interior of the large islands of the East Indies or on the remoter small ones. Traces of earlier populations that once lived in these islands can still be found scattered throughout the region. The primitive Australian aborigine must have passed through these islands on his way to Australia. Although little trace can now be discovered of him, there is much more evidence of his successor and follower, the Melanesian, who still reveals his presence in the population of the eastern islands of Indonesia. Pygmies similar to those found in Melanesia still survive in the Philippines. It is worth recalling that in the remote past one of the earliest and most primitive human types existed on Java. This is the famous *Pithecanthropus erectus,* whose fossil remains are dated as far back as a million years.

It is impossible to characterize the pattern of life in this area, as it varies enormously. Some cultures are quite simple and reminiscent of those we have already described. Others such as the civilizations of Java, of Bali, and of Sumatra, are highly organized, complicated societies with elaborate political and religious structures, magnificent art and architecture, native music and dances of extraordinary development, and a multiplicity of exquisite crafts and manufactures that bear comparison with our own. Indonesia is in reality a region where high civilizations have flourished long before the advent of the white man. It has had long and intimate contacts with the civilizations of the mainland: India, Malaya, and China. For centuries these islands have been the principal goal of Chinese emigrants, who were firmly entrenched in the commercial life of the islands. From these islands came at least one of the major elements in the Japanese population, and traces of this origin are still plain in Japanese culture.

OTHER PUBLICATIONS ON Peoples of the World

Order any of these items from Man and Nature Publications, The American Museum of Natural History, Central Park West at 79th Street, New York 24, New York. They are all published by the American Museum

PEOPLES OF THE PHILIPPINES. By A. L. KROEBER. *244 pages, 50 illustrations. Cloth bound. Second edition, revised. 1943. Price, $1.00; postage, 7 cents.*

This comprehensive handbook on a region that has become increasingly important in recent years should prove useful to men in the service and to students of anthropology, as well as to the casual reader. It presents an interesting account of the racial and cultural background of the islands and discusses the art, occupations, and religion of the natives. It is a valuable aid to the visitor in the Philippine section of the Museum, whose collections provide illustrations for many of the subjects presented.

THE INDIANS OF MANHATTAN ISLAND AND VICINITY. By ALANSON SKINNER. *64 pages, 27 illustrations. Paper bound. Fifth edition. 1932. Price, 20 cents; postage, 3 cents.*

Few subjects make a more forceful appeal to the student, historian, or even the general reader, than the native Americans who occupied what is now Greater New York. Yet it is very difficult to obtain information on them, for the few accounts which the Colonists left us are in tomes that are rare and difficult of access. This booklet briefly supplies the available information, discussing the life of the natives, their costume, religion, and archaeology.

THE MAORIS AND THEIR ARTS. By MARGARET MEAD. *38 pages, 23 illustrations. Paper bound. 1928. Price, 15 cents; postage, 3 cents.*

This traces the background of native New Zealand art through the organization of Maori economy, society, and religious life. It gives a description of the construction, decoration, and uses of their carved jade *hei-tikis*, their carved communal houses, and elaborately decorated wooden canoes. Weapons, textiles, and tattooing are discussed with special reference to the facial designs and the custom of preserving heads after death. Interesting to student and layman alike.

INDIANS OF THE NORTHWEST COAST. By PLINY EARLE GODDARD. *175 pages, 103 illustrations. Cloth bound. Second edition. 1934. Price, $1.00; postage, 7 cents.*

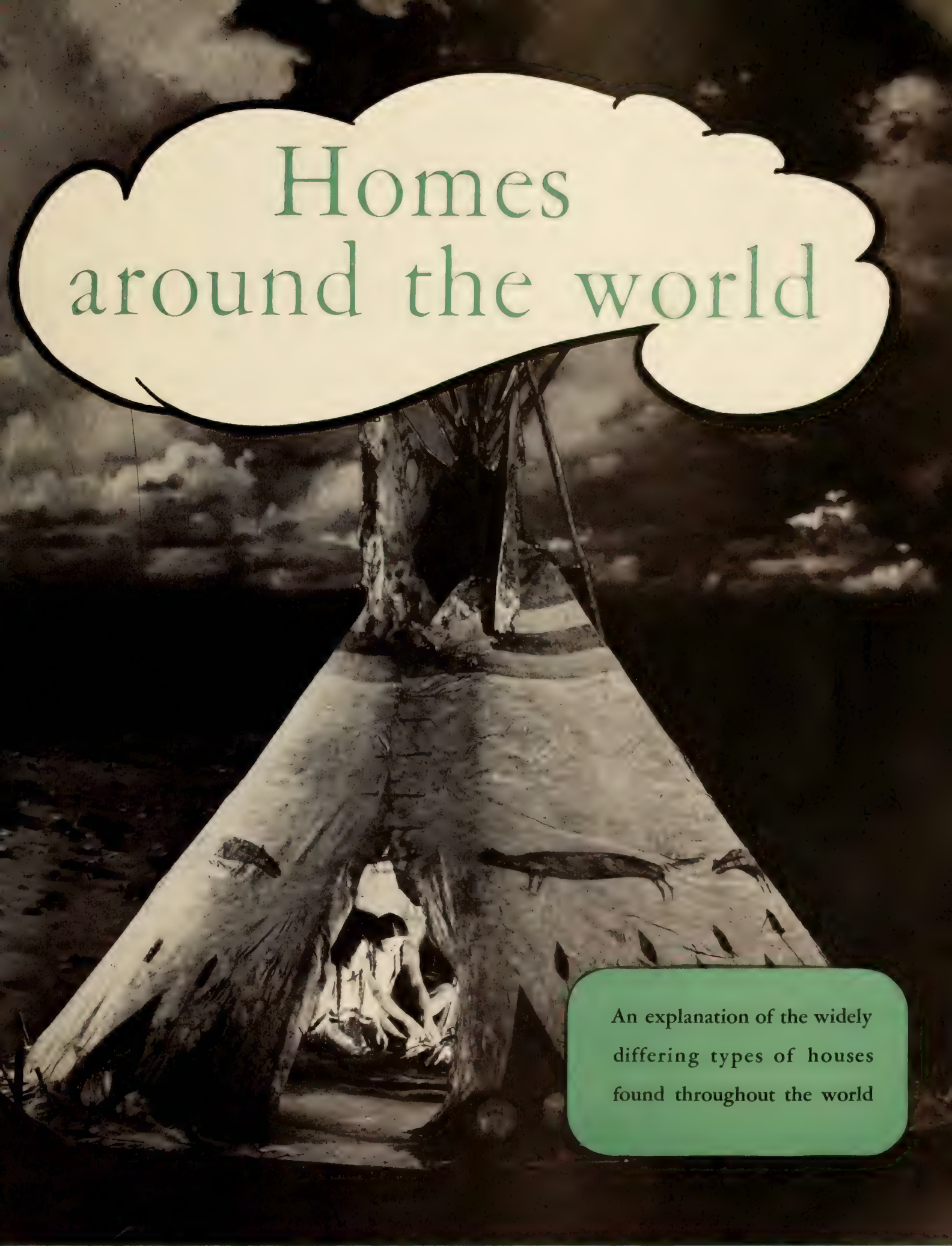
This plainly written account relating to the work and exhibits of the Northwest Coast Indians Hall in the American Museum is valuable not only to the visitor wishing additional information but also to anyone interested in the Indians of this area. It discusses the topography and climate of the territory along the coast from the Columbia River in Washington to southern Alaska, as well as the customs, religion, and art of its inhabitants, expert workers in wood and carvers of totem poles.

NORTH AMERICAN INDIANS OF THE PLAINS. By CLARK WISSLER. *172 pages, 64 illustrations. Cloth bound. Third edition. 1941. Price, $1.00; postage, 7 cents.*

This well illustrated and clearly written handbook is a summary of the facts and interpretations of the culture of the Plains Indians. It serves as a guide to the American Museum's collections and will give the visitor a broader understanding of the materials on display. Further, it acquaints the student and general reader with many of the basic points in the study of this North American Indian culture, including marriage, social and political organizations, and language.

INDIANS OF THE SOUTHWEST. By PLINY EARLE GODDARD. *205 pages, 71 illustrations. Cloth bound. Fourth edition. 1931. Price. $1.00; postage, 7 cents.*

This book will be useful not only to the Museum visitor who desires more information about the subjects illustrated by the collections in the Hall of Southwest Indians, but also to the student of American history and culture. It offers a review of the facts concerning both the prehistoric and historic natives of our Southwest. Among the subjects treated are the Spanish conquest, the Pueblo and Village Dwellers, the nomadic peoples, cliff dwellers, native weaving, the potter's art, and the Hopi Snake-Dance and other ceremonies.



Homes around the world

An explanation of the widely differing types of houses found throughout the world

By HARRY L. SHAPIRO

THE AMERICAN MUSEUM OF NATURAL HISTORY

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BE IT EVER SO HU

PART I

As thoughts turn more than ever to other lands and other climes, it is astonishing to discover how many curious patterns people around the world have followed in making themselves a home

ESPECIALLY impressive among the many interesting collections of the American Museum of Natural History is a large assortment of models illustrating the various types of houses built by primitive man throughout the world. This article is based on this collection.

In the Museum, the models are scattered through many halls; here a selection of the most significant ones is gathered together for the first time as a unit for study and comparison. Some of the models are portable and are circulated among schools along with other exhibits, by the Museum's Department of Education. Others are life-size replicas.

The scientific care with which they have been constructed can be understood from the fact that in many instances several years of study in a single group of people have preceded the actual construction of one of the models. The more elaborate ones required months of work by skilled technicians. The collection as a whole is probably the finest and largest in the world.—ED.

ALL PHOTOS A.M.N.H.

▼ NEAR THE TIP of South America we find the simplest of dwellings, a crude windbreak that serves as the only shelter for the Ona family in a chilly and windy climate. Being nomadic, the Onas must be able to carry their shelter with them in their wanderings in search of food. Six to sixteen skins of the guanaco, a relative of the llama, are used in one of these windbreaks. The hair is scraped off, and the skins are smeared with grease and red ochre



▼ PORTABILITY is again a vita feature of the tepee of the Plain Indian. But even where life de pends on frequent movement i search of game, the house provide



IBLE

By HARRY L. SHAPIRO

and Chairman, Department of Anthropology, e American Museum of Natural History

e than mere protection from elements. It affords privacy n the publicity of community and unites the family in mu- endeavor



IT IS NECESSARY, I suppose, if we are to get on with our daily tasks, for most of us to take for granted the paraphernalia, frequently ingenious, by which the human organism maintains its comfort and extends its powers. Yet it is a source of wonder how nicely every tool, every item of gear and equipment, every article of clothing represents an extension of the human body and its needs, and usually reveals a history of increasing adaptation and efficiency.

The house illustrates this principle perhaps as well as any other object of man's material culture. But in one respect the house is probably unique. All other inventions and artificial devices of human culture originate exclusively in *human* experience. Even the rudest tools known to us are human inventions. No animal, not even the anthropoid ape, has ever been known to chip a stone with deliberate intent to fashion a tool. They may use a stick, a stone, or even a coconut as a ready-made device, but they do not transform the raw product into something new by conscious and purposeful effort. Thus none of our gear, even in its most primitive forms, has any prototype among the subhuman animals.

The house, however, is the only exception to this rule. Its counterpart is widespread in the animal kingdom in the form of nests, shelters, hives, and various other artificial structures. And it is as truly an artifact as anything in man's equipment.

▼ THE ESKIMO snow house, perhaps more than any other dwelling, illustrates how a house surrounds its occupants with an artificial climate in which greater comfort, sometimes survival itself, is possible. The colder it gets outside, the warmer can the Eskimo heat his snow hut without weakening the walls. The interior can be kept well above freezing by burning the seal oil lamp, particularly if skins are pegged to the walls to form an insulating layer of dead air





▲ PEOPLE of the old Stone Age found shelter in natural caves and rock crevices. If they developed any sort of domestic architecture beyond the most elementary use of branches and leaves, all traces have been destroyed by time. This model, recently completed in the American Museum, shows human life about 500,000 or 600,000 years ago on the Somme River in France. (Chellean Culture)

▼ MAN'S EARLIEST HOME, the cave or natural rock shelter, has also been used down to recent times by some peoples. The model below shows one on the northern end of New York City's Manhattan Island (Inwood Park), a settlement that was occupied by Indians when this region first felt the influence of European civilization. Thus we see the earliest type of dwelling almost under the shadow of the tallest buildings man has ever contrived to build



THE precise evolution of the human habitation from its simplest precursors is difficult, if not impossible, to unravel. Primitive man, who often lived in caves where these were available, has thus far not provided us with any remains of his more ephemeral efforts to provide shelter for himself. The chances are that we shall never find any such traces, since the earliest representatives of mankind could have used only perishable materials for such structures. In all likelihood primitive shelters were of the crudest character, only little advanced beyond the nests that the anthropoid apes construct for themselves in the branches of trees.

Some writers have assumed that the origin of the house goes back to the use of caves, and that the evolution of masonry and stone construction arose out of the efforts of the cave dwellers to close the openings of their shelters with walls. This sequence, however, seems more fanciful than real. In the first place, primitive man probably inherited from his primate ancestors a tradition of nest building that he could easily adapt to his needs. Furthermore, masonry is by no means universal, and where it does occur it appears to be relatively late rather than early in the history of the house. In Europe, for example, remains of wattle and daub houses found as far back as the Neolithic antedate evidence of the use of stone construction.

In any event, it seems most likely that the house went through multiple lines of development, according to circumstances, rather than a single evolutionary sequence. It is more accurate to conceive of its development as varying among diverse peoples, taking directions that material, environment, and skill suggested. In some instances, indeed, little or no progress whatever can be detected, with the result that at present almost every stage of complexity may be seen in the contemporary housing of mankind. Men live in caves today, as they did 50,000 years ago. Windbreaks of the simplest construction serve now as they have in all stages of human history. This very multiplicity of house types found throughout the world leaves no doubt that the human habitation has had a complex history of development and adaptation.

The variety of house types in use brings to mind the old French saying, *"Plus ça change, plus c'est la même chose"*—the more it changes, the more it remains the same thing. The diversity of domicilary styles should not mask for us the fact that the basic needs a house is designed to satisfy are constant necessities which all forms of habitation serve with more or less efficiency and elegance.

storage

▼ GROWTH OF THE HOME beyond the limit of a single room was stimulated largely by the need of storage space for food, implements, and other goods. In this model of a Koryak village on the seacoast of eastern Siberia we see a small shed for such properties (*center foreground*). At extreme left is a storeroom on a platform for protecting winter provisions. It is elevated to keep the food from dogs and wild animals



storage



▲ A CORN CRIB constructed of cane illustrates the necessity for the storage of food among agricultural natives even on a relatively low stage of culture. This is a reconstruction of a Natchez Indian community in eastern central United States. The conical roofs of both the hut and the storage chamber are of matting. The "pyramid" in the distance, known through archeological excavations, presumably had some role in the spiritual life of these Indians

THE fundamental needs that a house must fulfill are simple and universal. A house or shelter must provide protection from the weather, from cold and snow in cold climates, from heat and rain in warmer ones. In a very real sense, the house surrounds its inhabitants with an artificial climate in which greater comfort is possible, and upon which, in certain severe circumstances, existence itself depends. The human organism by itself is not able to meet all the rigors of the weather. The natural protection that other animals have in pelt, hide, and fatty deposits is inadequate in man, who seems to have evolved in a warm climate where such anatomical accessories were unnecessary. But since he has ventured into every corner of the earth, into regions for which he was not adapted by nature, he has been forced to acquire an artificial protective device—the house. Indeed, one might argue that only the development of some form of shelter made possible the world-wide distribution of mankind that we see at present.

Aside from the physical shelter that a house provides, it also serves another universal need, the protection and storage of personal property. Although primitive man had few possessions and perhaps little need for storage unless he were fortunate to have an excess of game, man in his cultural advance soon began to acquire accouterments essential for his way of life and ornamental to it. These impedimenta, the personal assets we all treasure, must be kept and stored; they must be housed where they can be found when wanted; they must be set apart from the community property. If shelters and houses were not needed for man's physical well being, they would still be necessary to contain his equipment.

Indeed, when storage comes to occupy too large a space in the dwelling, man begins to build special houses to accommodate it. Food storage, especially in agricultural communities, requires this special housing, and in hunting groups such as the Eskimos special rooms or bays are built solely to accommodate reserve food and gear. Even in highly complex societies, like our own, this primary function of the house has remained intact, although with the necessity for large-scale storage of various commodities, special independent structures like warehouses and barns have evolved out of a province that once belonged exclusively to the house.

home as a refuge

To these basic requirements of the generic house may be added a less tangible attribute. The house or home represents a haven and a refuge. It provides an oasis of privacy in the midst of the publicity of community life. To have a room of one's own, a sanctuary, is a profound and common need. The child who discovers a secret cave where no one can find him, or builds for himself in the backyard a little shelter out of a packing case and stray lumber, into which he can retire as into a private world, reflects a profoundly human craving. It would be difficult, however, to determine whether such a feeling leads to building a house or follows from the possession of one.



➤ EVEN IN THE PRIMITIVE COMMUNITY, where each family seldom has more than one room, the home is a refuge and a haven, satisfying the human yearning for privacy. A Blackfoot tepee

▼ PRIVATE SLEEPING COMPARTMENTS provided seclusion in the earth-covered lodge of the Hidatsa Indians of North Dakota. The frame of one of these compartments without its skin covering is shown at lower right. One side of the lodge has been cut away in this model to show the interior. The only openings in such a house are the door and the smoke hole in the roof. Houses of similar construction were used by most of the semi-agricultural Indians of the Plains. The tepee was their temporary dwelling





▲ Whether on America's northwest coast as shown in this photograph, or elsewhere in the world, the plank-built house follows a certain general pattern. This is a village scene among the Kwakiutl Indians, reconstructed in miniature as an exhibit in the American Museum. Heavy cedar posts support the plank roof. In the older type of house (*at left*) the walls were made of overlapping planks tied to upright poles. The houses face the sea, and there are platforms in front on which the Indians pass much of the time in fair weather. These houses are decorated with elaborate carvings and paintings expressing mythological and totemic beliefs of the tribe

▼ Use of grass as house-building material, widespread throughout tropical and some temperate regions, naturally imposes an architectural style quite different from that of the plank house. This is a model of a Congo hut



influence design

ALTHOUGH, as we have seen, the house has come into existence to serve simple and universal physical necessities, it has nevertheless acquired a vast and fascinating variety of forms, materials, and constructions. There seem to be almost as many kinds of houses as there are styles of clothing. Leaving out of consideration the complex houses of civilized man, I shall attempt to indicate the range of this diversity as it exists in the domestic architecture of the simpler cultures. And I shall try to indicate some of the factors and circumstances that dictate this variation.

What is it, one may ask, that has brought about the multiplicity of domiciles even among people on a relatively simple level of culture, if, indeed, the house is basically designed to serve such universally shared necessities as shelter, storage, and privacy? Moreover, if these needs are determining factors, why do the various forms of habitation not fall into a simple progressive line of increasingly perfect accommodation to them? There is no single answer to these questions, largely because these needs vary in their intensity and because the environments in which man lives are diverse. Moreover, numerous solutions are sometimes equally satisfactory even under uniform conditions. And finally, the creator of a house is a social creature, subject to a variety of influences emanating from tradition, knowledge, taste, and mode of life, which he embodies in all that he creates. It follows, therefore, that while the fundamental incentives to house building may be reduced to a few, the expressions to which they give rise may be and are many.

The material of which a house is constructed not only lends its character to the appearance and purpose of the structure, but it often dictates the method of construction. It is obvious that the use of planks and boards demands a framing quite different from the palm house. Furthermore, shapes that are feasible in one material are awkward in another. The circular, domed or conical forms, which are readily constructed out of fibers, leaves, grasses, or mud-covered wicker frames, are unsuited for wooden construction.



▲ DEEP IN THE ITURI FOREST in Africa, the pygmy builds a small beehive hut of broad leaves. It sheds rain well but is tiny even for the diminutive people who build it. The hunter has just returned successful. As a result the hunting dog has been permitted to wear his wooden bell



▲ A CUT-AWAY SECTION of a model of a bark hut of the Ojibway Indians. It shows one of the basic patterns for a light but strong dwelling built in the shape of a dome from materials widely available

many different



stone and mud

◂ STONE AND SUN-DRIED BRICK, generally whitened with gypsum, are used in the construction of the compact Hopi village clusters. The women take an unusually active part in house-building, but the men are apt to lift into place the heavy beams, whose ends are seen projecting through the masonry in rows. The roofs are of cross poles, brush, and clay. Many of the rooms in the lower terrace are for storage

wattle and daub

▸ THATCH-COVERED wattle and daub houses like this are seen in various parts of Europe today, yet this is a model of a Neolithic house that was used in Denmark in about 2700 B.C.



aterials——

MAN has shown a remarkable ingenuity in his use of natural materials for building his shelters. He has employed stone, coral, brick (often in the form of sun-dried or adobe blocks), plaster, cement, mud, dung; loose, rammed, or root-bound earth; logs, planks, branches, vines, bark, leaves, reeds, grasses, skin, felt, mats, and even snow.

thatch and wattle



▲ THATCHING was tied over a frame like that of the Ojibway bark hut (shown previously) in the dwelling of the Shinnecock Indians of Long Island. Overlapping layers like this are remarkably effective in shedding rain



snow

◀ THE ESKIMOS build their snow huts by a totally different principle than that of other dome-shaped dwellings seen throughout the world. The blocks of snow are laid in a spiral. As the wall slopes inward toward the top each new block is supported by the one next to it. The Eskimo must travel light and is obliged to live at some seasons on the floating ice of the sea, where other materials are not available. His unique dwelling gives striking evidence that necessity is the mother of invention. It can be built in an hour, and all the builder needs is a snow-knife



skins

◀ SNOW HOUSES MELT with the approach of the warmer season, and the central Eskimos then live in skin tents. The poles are usually of driftwood

many different materials



birchbark

THE INDIANS of the Eastern Woodlands constructed a conical tent of birchbark almost the same in pattern as the skin-covered tepee of the Plains

THE LOG CABIN was originally neither Indian nor English. The idea was introduced by the Swedes who settled on Delaware Bay in 1638. The Indians of the South took it over and soon forgot they had ever lived in any other kind of shelter. This example is from the Yuchi Indians of Georgia. The log cabins built by the Indians had no chimney, only a smoke hole in the roof

logs



protection from . . .

It is difficult to generalize for all types of houses, but the environment generally guides the choice of material. This doesn't mean that building materials are uniform in similar environmental areas, although broad similarities do exist. It is rather that the environment tends to discourage the use of unsuitable stuff when more efficient material is at hand.

I may illustrate this by pointing out that in cold areas non-insulating materials are highly unsatisfactory, so that such climatic conditions tend to rule out at once the mat houses of the Philippines and the grass houses of Africa and South America.

This certainly is the tendency, although I must at the same time recall that the birchbark lodge of the Northeastern Indians and the lightly constructed Japanese house are not particularly well adapted to their environments. Perhaps stoicism and tradition in these cases rise superior to the discomforts of the weather. Conversely, in the hot moist climates, a heavily constructed and insulated house is less desirable than one of light construction with walls permeable to currents of air. As a result, not universal by any means, the tropic dwellers tend to build with grasses, palms, leaves, and other materials that permit ventilation while providing shelter from sun and rain.

Hot dry climates, on the contrary, call for thick walls, and again we see in the adobe house of the Southwest the selective power of the *milieu*.

cold



➤ **Many people living in the Arctic build houses that are partly underground as protection from the low temperatures of winter. The example shown here is from the Maritime Koryak of eastern Siberia. A long passageway leads into the house, but in winter this is closed off and the house is entered through the smoke hole in the roof. The smoke hole is protected from drifting snow by a funnel-like platform. People in cold climates frequently sleep on platforms, because the warmer air rises**



humidity

➤ **On the tropical headwaters of the Amazon in northern Peru, the Chama Indians live in houses that are open on all sides to assure maximum ventilation in a hot climate. The roof sheds rain well but is also porous to air. These Indians do not sleep in a hammock like many others in the Amazon but upon mats spread on the floor. The house furniture is simple, but they strive to beautify everything they make**

protection

the

▼ WELCOME SHADE is found under this flat-topped shelter of the Apache Indians. Rain is no great problem here on the arid plain near the San Carlos River in Arizona, so a flat roof is as good as a sloping one. In summer much time is passed by these Indians under this shelter, which is open to the breeze on two sides. For many generations the Indians have cultivated their fields of corn in this valley. The woman at left is applying melted pitch to a water basket; the man is making arrows





rain

◀ SLOPING ROOFS OF THATCH, generally porous but water-tight, are characteristic of native houses in the tropics. So are raised floors and well-ventilated foundations. These and other typical aspects of life in the tropics are illustrated here in a model of a village in the Philippine Islands

rom

un

▼ THE FLAT ROOF OF DESERT REGIONS is seen again in this view of a model of the ancient city of Ur. So far as architecture is concerned, the climate here at the confluence of the Tigris and Euphrates is the same as that where the Apaches live—hot sun, dry air, and only slight rainfall. The flat roofs and mud construction, still predominant in the Near East today, would not withstand heavy rain. But they are admirably effective in dry climates where shade makes the difference between scorching heat and pleasant coolness



▼ LIVING IN THE SWAMPY EVERGLADES of Florida, the Seminoles have developed a house that gives the maximum protection against the effects of dampness below as well as above. Raised on posts and sheltered with thatching against the rain, the living quarters remain open to the drying breezes and thus are light and airy

damp earth



THERE'S NO PLACE LIKE

PART II

Mode of life and social organization influence house type: man's relations to the natural world and his concepts of society are reflected in his domestic architecture

HOUSING or shelter of some kind is a universal need. It provides man with necessary storage space for his gear and supplies, it surrounds him and his family with privacy, and especially it creates a climate which contributes to his comfort or enables him to live in areas which otherwise would be impossible for human habitation.

Man has developed an enormous variety of house forms and has utilized an astonishing number of materials. Not always, however, is the construction or the material the most suitable. In certain areas and circumstances the choice of a building material is limited by its accessibility. For example, the pioneers who settled the treeless plains of the Mississippi Valley found themselves without a local supply of the materials traditional for house building in the areas from which they migrated. Logs were unavailable or scarce. Stone or cut lumber meant a long expensive haul from the East. Sod, however, lay everywhere underfoot, available to anyone at the cost only of his own labor. As a result, the "soddy" or sod house became the common dwelling of the pioneer. Its form followed accustomed lines. It was rectangular with doors and windows and resembled, except for its material, the familiar cabin.

It is interesting and significant that these pioneers did not adopt a form of shelter already widely used in the very area where they were building their sod houses. The Indian tepee, built of skins stretched over a frame of poles, might have served as a model for newcomers, since skins were easily obtainable from the vast herds of bison and construction of the tepee presents few engineering difficulties. Despite its convenience, it was rejected, because the tepee is a relatively inefficient shelter against cold. Although its thin skin covering, pegged to the bare ground, sheds rain and snow well enough and provides a welcome shade in the summer sun, its insulating value in below zero weather is negligible. Its redeeming virtues were the ease with which it could be assembled or dismantled and its extreme portability. For the nomadic tribes of the Plains these were prime considerations. They were, however, of no value to settled agriculturists who expected to remain on their quarter sections and who welcomed permanence.

Under the circumstances, therefore, sod or earth were the only choice open to the pioneers, who solved their problem in a fashion not too dissimilar from the semisubterranean earth lodges of the more permanently settled Mandan and Arikara, who were also inhabitants of the Plains.

Where the circumstances are not as stringent as this, tradition may influence the choice of material, as may be seen from another example from our own architectural history. The first English settlers in New England brought with them from East Anglia a familiarity with wooden frame construction. They found in their new homeland an abundance of wood, as well as of stone and clay for bricks. Wood, it happens, was universally adopted in preference to the more permanent stone and brick, partly because the trees had to be felled anyway in clearing the land, but also because the settlers' knowledge of house building was based on wooden models in the old country. Thus, tradition was largely responsible for filling New England with wooden houses.

But farther south, the Dutch and Germans, who found a forest as abundant as in New England, preferred to build in brick and stone because they were already adept in the use of these materials in house construction. When the Western Reserve was made accessible for settlement, the New Englanders who migrated to this newly opened territory carried with them this already long established habit of home construction. In such early Ohio towns as Marietta, houses still stand that are faithful to the New England styles of the eighteenth century. Although time has changed the architectural detail, it would be interesting to know how much of the persistence of wooden frame construction in the United States today survives from the New England tradition established three hundred years ago.

Where the level of skill or culture declines, the influence of the environment becomes progressively ineffective in suggesting the best material or the most efficient construction. Thus we find the unfortunate inhabitants of the cold, raw land of Tierra del Fuego, who exist on a low level of culture, shivering behind their inadequate windbreaks, miserably protected from cold and wet.

All photos A.M.N.H.

▼ WINTER FINDS many natives confined to small, portable dwellings, prevented from using larger and more permanent shelter by the necessity of conserving heat and of moving in search of food. Here we see a camp of the Kutchin Indians on the upper Yukon in eastern Alaska as they



OME



bserved about 1850. The Arctic Circle
hrough their country, and the winters
g and cold. The usual type of winter
as shown here, is dome-shaped, with
poles supporting a skin cover. Sleds
by dogs are in use, and hunting
hing are the chief occupations

▲ A CRUDE WINDBREAK and the simplest of skin clothing constitute the only protection enjoyed by these Tehuelche in their chilly homeland near the southern tip of South America. Their tent, or toldo as it is called, is an interesting illustration of evolution in house design. Four centuries ago, at the time of Magellan's historic voyage, the Tehuelche lived in an even smaller and simpler shelter resembling that of their neighbors, the Onas (illustrated in the previous chapter). But, like some tribes in our own country, they soon learned to use the European horses, and by 1750 they had become a tribe of horsemen accustomed to treks through thousands of miles of country. This permitted them to carry this larger shelter. Notice that even the baby's cradle has been altered to fit across a pack load

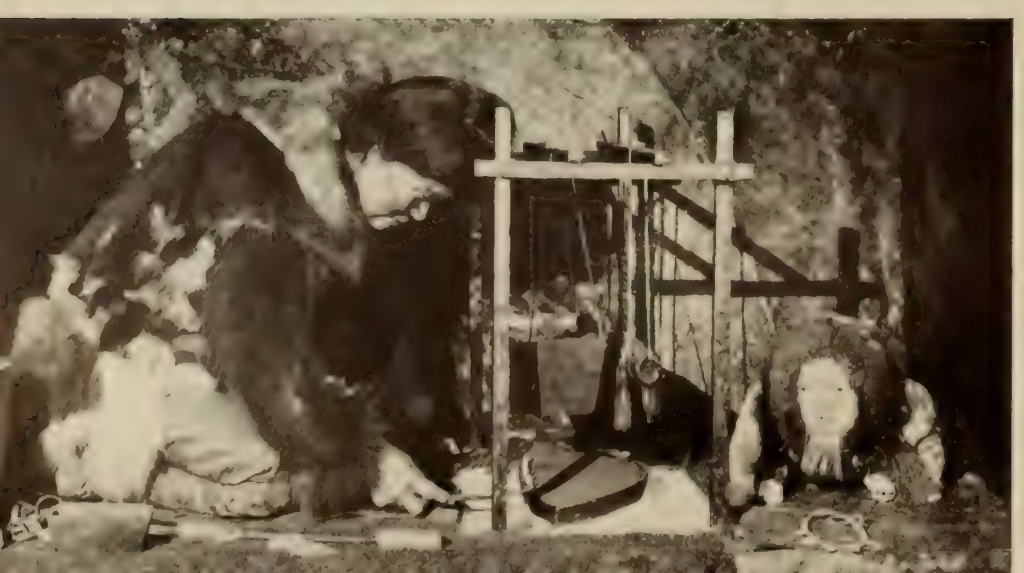




THE NECESSITY OF TRAVELING in search of food requires the Eskimo to move all his worldly belongings in winter on a sled. He has solved his house building problem so effectively that he needs to carry only a snow knife in order to construct a dwelling in which he can live comfortably for weeks or months



A SHORT TUNNEL and protecting wall bar the doorway from bitter winds and provide shelter for the dogs. Illumination within is improved by a window of clear ice, here seen above the door



the home

WHEN the natives are ingenious and skilful, we see remarkable adaptations to material and weather. The Eskimos' invention of the snowhouse illustrates how the ingenuity of skill can overcome the rigors of climate and the paucity of material to produce a satisfactory solution to a difficult problem. In this instance, the specifications are formidable. The Eskimos normally live in semisubterranean sod or stone houses, but certain groups who travel during winter and pass considerable time on the sea ice need another kind of house. Since the winter temperatures are extreme, this dwelling has to provide warmth and protection from the cold. Moreover, the material has to be something easily available, because the only method of transportation, the dog sled, rules out the possibility of carrying suitable building material. Skins or felt are inadequate to the conditions, and stone or wood are too heavy and cumbersome for building when speed is essential. Digging a semisubterranean shelter is impractical in winter even on land, for the earth lies solidly frozen beneath the snow, and of course impossible when traveling over the frozen seas.

Without some kind of an answer to this problem, winter travel would be out of the question, and hunting —a constant necessity for the Eskimo —would be dangerously limited. The genius of the Eskimo surmounted these obstacles in his invention of the snowhouse, which can be erected within an hour out of material everywhere at hand and in which he can live in comfort.

THIS INTERIOR of an Eskimo snowhouse exhibited in the American Museum shows the skins that are sometimes pegged to the snow walls to give greater insulation from the cold. Eskimos frequently remove their upper garments in the snowhouse, because the temperature is brought well above freezing. The seal oil lamp that the woman is tending here is a shallow stone receptacle for blubber. The melted blubber burns through a moss wick

f the traveler



↑ RELIANCE UPON MATERIALS easily available has resulted in the elaborate use of birchbark by the roving Ojibway Indians. Note that two shapes of shelter are constructed with the same material, one dome-shaped, the other conical. In the center a birchbark canoe is being made, and at left an Indian is stripping the bark from a tree



← THE CREE INDIANS near Hudson Bay also use a tepee covered with birchbark. Sometimes caribou skin is used instead. These Indians make extensive use of rabbit skins for clothing, in the production of which the women shown here are engaged

AS MANY AS SEVEN or eight persons live in one of se huts used by the Alacaluf Indians in an exceedingly ny climate near the southern end of South America. ır sticks are put in the ground and bent over to form o parallel hoops. Other poles are then forced into the ound and bent across in the other direction, and lighter es are added to complete the dome-shaped frame-rk. Ten to twelve sea lion skins form the covering. e two doors at opposite sides are screened against the nd by fern fronds. A fire is built in the center of the and the occupants sleep at either end. When they vel to another location, they take only the skins with m



the permanent



▲ IN CONTRAST to people who follow a nomadic existence, those who pursue settled occupations such as farming are apt to be found living in permanent dwellings. Even in about 2700 B.C. the Neolithic people of Denmark are known to have erected substantial houses of wattle and daub, as illustrated in this model. The mound in the background was used for burial purposes



ome



ALTHOUGH the material may influence the design and structure of a house, it is not the only criterion by which houses are differentiated. The manner in which a building is employed may be as important as, or even more important than, the material itself.

The birchbark and the skin tepee, while differing in material, are essentially the same in structure and design. Similarly, stone or brick may be used interchangeably with little or no modification in the type of house itself. On the other hand, the same material may be applied to structures widely divergent in design. The domed shelters of the Winnebago, the tepees of the Ojibway and the Cree and the lodges of the Iroquois, despite their variety of shape, size, and construction, were all covered with bark. In distinguishing these abodes architecture is obviously more important than the nature of the covering spread over the skeleton of the building.

MOST of the house types among the uncivilized folk of the world are one-roomed affairs in which the high degree of room specialization familiar to us is absent. Here a single room contains most if not all the activities that we disperse among kitchen, bath room, dining room, living room, and bedroom, not to speak of the libraries, music rooms, game rooms, bars, offices, dens, studies, etc., of more elaborate establishments. The departures from the basic one-room plan and they are never very great, can usually be traced to specific circumstances in the life and environment of the inhabitants.

In warm climates, where the heating problem is not acute and the warmth generated by cooking need not be conserved, detached kitchens are often found. Where special structures are not put up, the cooking may even be done out of doors.

Agricultural people, who must store food in large quantities, frequently build for this purpose special storehouses or rooms as in the pueblos of the Southwest. But in general, a single room suffices, and may in cold regions be necessary in order to take advantage of every source of heat, artificial and human. Anyone who remembers an old-fashioned farm house in winter with its annual contraction of domestic life to a single room, usually the kitchen, can readily appreciate the advantage of the one-roomed dwelling.

◂ A GABLED HOUSE of bark is the home of the Sauk and Fox Indians west of Lake Michigan. Their elaborate use of basswood in the making of useful articles is illustrated in this model

▾ The Navajo Indians of Arizona and New Mexico build this characteristic log and mud house known as a hogan. Their life centers around the cultivation of corn and the tending of sheep, whose wool is woven into blankets as shown here



In more beneficent climates, sleeping quarters may be divided from the main room, and even special houses are sometimes erected where the young men of the village retire to sleep.

AMONG most people, the house is designed to accommodate a single family and is therefore small. These small units, however, have a definite relationship to each other. With the few exceptions to be mentioned, these units are detached but arranged in a village pattern, usually either along a street or in a circle. The latter arrangement, adopted by the Plains Indians, provides some protection against attack by hostile neighbors. Walls, too, are often an essential part of the village design either for defense or to enclose domestic animals. The famous kraals of southeast Africa were regularly surrounded by a stake fence within which the cattle could be confined. Walls to ensure family privacy are also known in rather more complex groups. The compound with its surrounding wall, found in Malay groups, is an example of this, and analogies to it exist in other parts of the world as well.

One of the most interesting village arrangements in aboriginal America is the pueblo of the Southwest. It is a single structure consisting of attached units all forming an apartment-house-like building, in contrast to most villages, where the family units are detached and separate. The pueblo takes several shapes but typically rises several stories, with each one set back from the one below it.

These examples of house plans and village arrangement are all drawn from social and familiar structures where each family inhabits its own private dwelling. Social custom, however, may decree a more intimate form of living. In such societies we find communal houses occupied by several families (such as the long house of the Iroquois) or even by the entire village where such groupings are small in size. The dwelling then becomes considerably expanded in order to shelter under one roof a relatively large number of people. The Iroquois long house was often from 50 to 100 feet in length, and the Haida built substantial communal structures 40 by 100 feet. Each family usually had its own recognized section of the large hall-like interior, where it might store its goods and possessions and where it could retire to sleep. Thus, social organization, mode of life, and climate tend to modify and control the house plan and the village arrangement.

community

▼ ARCHITECTURE and village plan usually reflect the community life of the people. Even as long ago as the time of the prehistoric Swiss lake dwellers we find an orderly arrangement of houses forming a well-knit social unit, as shown by this scientific reconstruction based on archaeological evidence. A narrow wooden causeway, easily defended against enemies, connects the village with the shore. The people belonged as much to the world of water as to that of land, but the social life was circumscribed and conditioned by the narrow boundaries of their pile-supported village platform. A foundation so difficult to build would be expected to do for many generations



ife

▲ AN "ISLAND WORLD" of a different sort is embraced within the walls of the Hopi pueblo. Community life there fits into an environment of roof tops. These houses are built and owned by the community instead of by individuals or families. The woman at left is making a coiled basket; the one in the center is "building up" a pottery vessel by adding successive rounds of clay

▼ ON FIRST VIEW, the compact Hopi pueblo, accommodating many families on different levels, suggests certain resemblances to our city apartments. But its community life is much more intimate. Everyone knows everyone else, and the various roof levels, accessible only by ladder, interconnect with one another



UNQUESTIONABLY one of the most distinctive features in a house is its method of construction, by which I mean not only the manner of building the house but also its relationship to ground level, and its decorative features. If we include as houses all kinds of shelters, they may be classified into the following basic forms: open shelters (lean-to's and windbreaks), the circular house (either dome-shaped or conical), and the rectangular house with pitched or flat roof. Variations and elaborations of these typical forms are, of course, numerous. I have not included caves in this classification, because they are natural phenomena, exhibiting no evidence of human construction. A claim might of course be made for the artificial caves used by some of the Chinese or masonry-fronted caverns of southwestern Europe.

The open shelter may consist of a series of stakes or branches joined to form an open shell-like structure, covered with leaves, skins, earth, or some other suitable material. It may also be a simple wall to deflect the wind, or it may be a lean-to type where the wall is inclined to form a half roof. These devices, which are of the most primitive character, are nevertheless widely distributed. The Australian aboriginal often uses nothing more. The Apache of the Southwest sought protection behind a similar screen. I have seen natives in the Malay jungle bedded down under such an open-sided shelter that was covered with broad leaves as a kind of thatch. It is at best a makeshift and suitable only as a temporary lodging for nomadic people living in warm climates, where its ability to shed rain may justify it. To find such a poor protection in common use among the Ona of Tierra del Fuego, where cold wet winds are frequent, seems contrary to the rule that man adapts his shelter to fit the environment.

The circular and the rectangular house are fundamentally distinct in their structure. In the former the roof or covering is often a continuation of the walls, which must therefore slope inward. This type of construction simplifies the problem of the roof and renders the circular house a highly desirable form under certain circumstances. Some circular houses do, however, have distinct roofs with overhanging eaves. But this shape, of course, limits the size of the house, since too great a diameter would create engineering problems of considerable magnitude.

There are many variations in the basic plan: the beehive house found in Africa, the simple dome covered with skins or felt among the tribes of Northern Asia, and the classic tepee of North America. Fibers, grass, mats, and mud can generally be applied effectively as a covering, but other materials too are used. The skeleton is generally a simple one of poles, interlaced branches, or of horizontal members tied to uprights set into the ground. Among the Eskimos, where wood is often hard to come by, the native builder has sometimes used the curved jawbones of the whale for the frame, covering it with sod.

The rectangular house represents a more adaptable form of dwelling, since it allows greater floor space and more head room. At the same time, this type of house may be enlarged without overtaxing the architectural skill of the primitive builders and becomes, therefore, the preferred form where engineering knowledge has advanced but not yet reached the virtuosity required for large domed edifices. One of the major problems presented by the vertical wall is the break between the roof and the wall itself, which must be protected from leakage. In dry climates a flat roof is generally adequate, but in areas of abundant rain or snow, the roof must be pitched sufficiently to allow water to drain off rapidly. It is necessary, furthermore, to protect the top of the wall from absorbing moisture directly from the rain or from the runoff. The roof, therefore, becomes a cowl resting on the walls by means of a series of rafters, which meet along the ridge and project beyond the walls as eaves. This technical solution to the problem makes it possible for the builder to widen his dwelling, which he does at the expense of heavier wall construction, to support the increased weight of the roof. The simple pitched roof is by far the commonest form among these structures. Intersecting roofs with troublesome valleys at the junctions are never attempted by the primitive. The other two roof constructions in modern dwellings, the lip-roof and the mansard, are unknown. All the most highly evolved houses found among uncivilized natives belong to the rectangular category, and in such forms as the plank house of the Northwest coast or the elaborate houses of the Mernagkabau of the East Indies the architectural knowledge displayed is very impressive.

ALTHOUGH modern architects have become increasingly concerned with the relationship of house to terrain and have achieved novel and interesting adaptations to land contour, their purpose is largely esthetic. The primitive builder, on the contrary, builds his house in relation to the land on more practical considerations, but he manages in certain instances to achieve notably pleasing results. Not only does he build conventionally, resting his house directly on the ground; he also goes underground and above the ground.

The true underground house has no counterpart in modern domestic architecture, yet it is a most efficient manner of insulating a dwelling from cold by making use of the same principle that keeps our cellars warm in winter. It is a form of construction found only in the most rigorous climates. The classic type is the Koryak house of northeast Asia, but variations where the excavation is shallower are found among the Eskimo and among the prehistoric people of the Plains. In fact, the semisubterranean house has been traced over a large part of Eurasia and North America. It is possible that the subterranean ceremonial kiva, in which the Pueblo Indians perform their sacred religious rites, may be a survival of an underground house type once employed by their ancestors when they ranged farther north, just as our own religious architecture tends to preserve antique styles long abandoned for secular construction.

ELEVATING the house off the ground is achieved by primitive builders by means of stone platforms, by piles, or by building in the trees. The Marquesans, for example, set their dwellings on stone platforms which formed a terrace surrounding the house. The use of wooden piles for supporting a house is fairly common, the earliest known being the prehistoric pile dwellings in the Swiss lakes. Modern examples may be seen in tropical America and various Pacific Islands.

There are several reasons for adopting this method of construction. The most dramatic is the protection that a pile-dwelling, set in a lake, lagoon,

or along the shore, affords its inhabitants. Since a dwelling enclosed in such a natural moat cannot be approached on foot, a measure of safety is thus automatically assured. Some of the villages in the lagoons and along the shore of Melanesian Islands are said to have been built by people who formerly sought refuge there from their land-based enemies. Such a strategic retreat could prove a blessing for fisherfolk, who would find their source of food conveniently at hand.

Tree dwellers such as the Gaddang and Kalinga in Luzon and the Manobo and Mandaya in Mindanao set their dwellings as high as 40 to 60 feet in the branches of trees. These lofty eeyries provide an excellent protection from human enemies.

Pile dwellings, more prosaically, by raising the floor of the house above the ground also offer another kind of protection—relief from vermin, animal incursions, and the humid exhalations of damp village sites. Native housekeepers find their superior elevation a convenience in their domestic tasks, since garbage may be easily disposed of below the house where the scavenging pigs of the village have free access.

protection from enemies

▼ **Tree dwellers in the Philippines build their houses as high as 40 to 60 feet above the ground and thus secure excellent protection from human enemies. This is a full-size model on exhibit in the American Museum of Natural History**



protection from enemies

PROTECTION AGAINST ENEMIES was attained to an extraordinary degree by the builders of the cliff dwellings in Southwestern United States. Extremely long ladders were sometimes the only avenue of approach. Protection from the rain was usually given by the overhanging cliff above. The stone and adobe buildings were plastered in a color closely resembling that of the surrounding cliffs. This model is a replica of a cliff village in the Canyon de Chelly in northeastern Arizona



The Zulus of Africa protect their cattle within a double circle of fencing, with the village huts occupying a unique position between the two rings



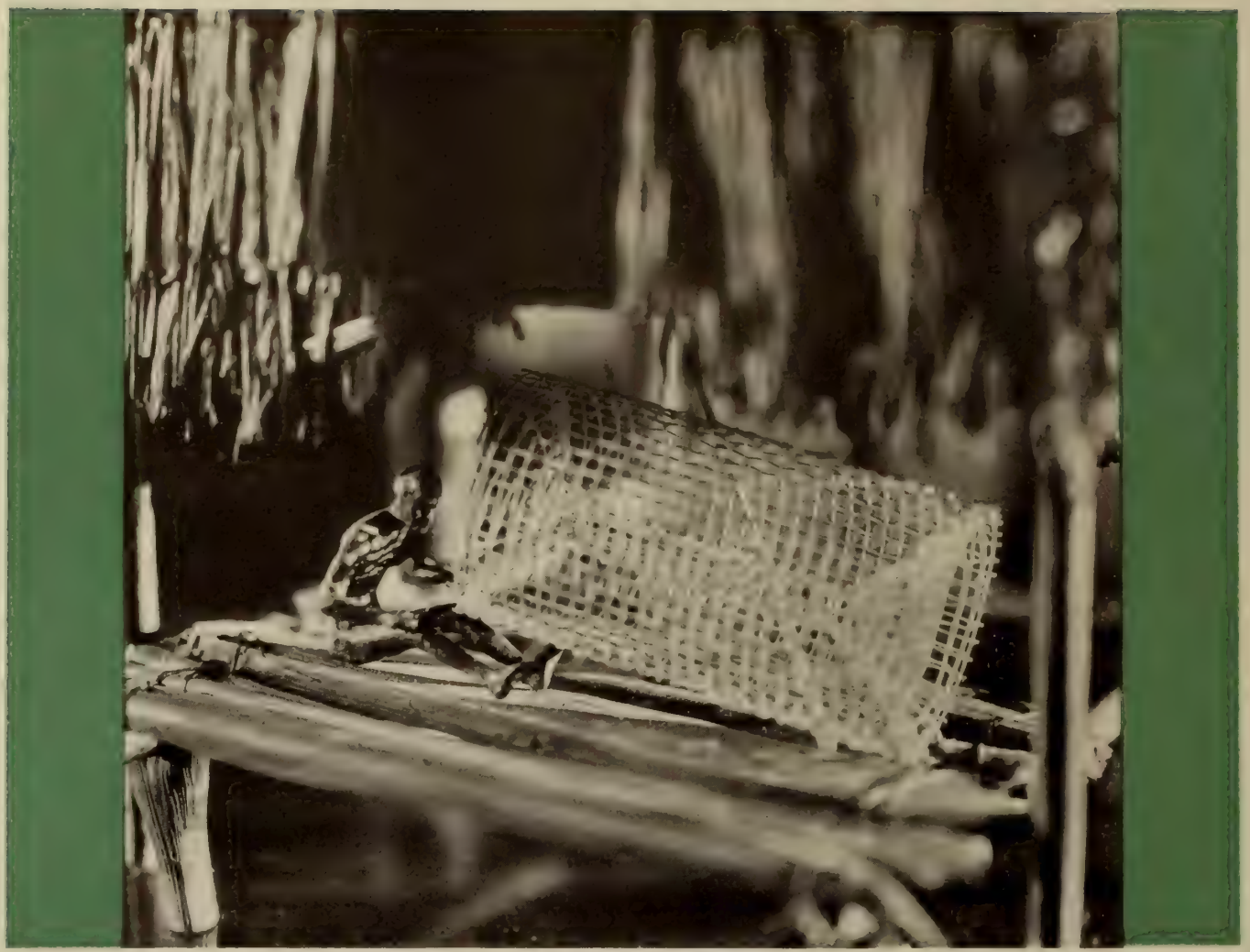


▲ THIS MODEL OF A VILLAGE of the Manus tribe in the Admiralty Islands is a beautifully executed example of house design showing the community life of a people who dwell over the water. For all the necessities of life, these people depend upon their skill in fishing and in navigating their large outrigger canoes. They trade fish for vegetable food and for wood for their houses and canoes. Note that the natives have painstakingly built up in the sea a small island of coral rubble to serve as a "town hall," where important meetings take place. Elaborate feasts connected with marriage, birth, and death enliven their isolated community life

a village over a lagoon

▼ THE PEOPLE OF THE MANUS tribe make voyages to distant islands in sailing canoes like the one reproduced here in miniature. A cargo of pots is being brought as a handsome gift to the kindred of a young man who is about to be married. His relatives have already paid many hundreds of dogs' teeth to signalize the marriage





▲ A DETAIL VIEW from the model of the Manus village showing the construction of a cylindrical fish trap. Many important phases of the life of the people are shown within the single model. Such an exhibit is possible only after many months of scientific study among the people. The investigator may have to learn to speak the native language in order to secure all the necessary information. In addition photographs and drawings aid the Museum's technician in reconstructing such a model

▼ EVERY OPERATION in building the full-size house is performed by the model maker, who thus produces in miniature an exact scientific replica of the original

◣ IN THIS INSTANCE, before the model house is completed its inhabitants must be put inside, because one is intended to see them busy at their daily tasks through an opening left in the roof

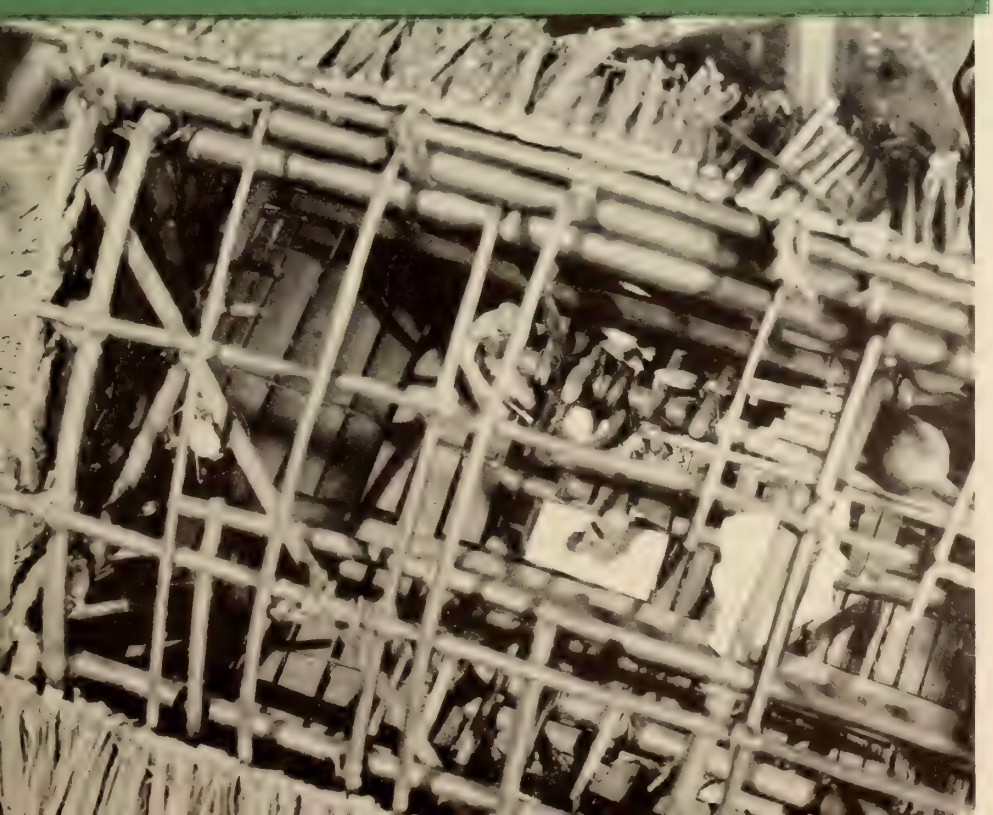
▶ THUS, THROUGH the blackened rafters one sees the woman of the house preparing a meal of fish







▲ SCRUPULOUS attention to detail is observed in every stroke of the knife in fashioning the smaller objects for one of these models, in this case an outrigger canoe, identical except in size with those used by the Manus tribe



WHATEVER beauty most types of native houses possess is functional and accidental. It springs from the quality of material employed and the surface it lends, from the shape and mass of the house itself, and from the structural details of the building. The esthetic distinction not infrequently evident in these simple houses does not represent a conscious striving for an effect; it is the natural result of the construction.

I recall vividly the pleasing effect which the under side of a thatched roof produced in the interior of a Polynesian house in which I once lived. The steep, lofty rafters, completely exposed from below, were covered by overlapping layers of thatch, narrowly spaced. This simple, functional finish was perfect in itself and needed no further adornment.

In a few noticeable instances, how-

ever, the native builder does consciously attempt to enhance the beauty of his work by additional details that have no purpose save to enrich the architecture. The Maori of New Zealand elaborately carved the gables of his house with fine scroll and openwork inlaid with shell, and he frames the doorway with similar decorations. Carved and painted designs of great elaboration are used by the Tlingit and Haida to embellish their houses. House decoration reaches a very high level in the East Indies, where carved and decorative elements are frequently incorporated into the façade and gracefully curving roof lines, and where telescoped gables and sweeping eaves are exaggerated for their esthetic values.

Some of the most interesting examples of primitive house decoration are the molded walls of African mud houses. The plasticity of this material lends itself particularly well to the vivid fancy of the African natives, who often achieve very striking effects by simple means.

The house, however humble, embodies and reflects so much of our history, our traditions, our skill and culture; it speaks so eloquently of our opportunities and our failures that one can't help agreeing that where'er we may roam,—"there's no place like home."



▼ The natives of New Zealand, the Maoris, spared no pains in applying their high skill as wood carvers in the decoration of their houses. The style of decoration in which they have distinguished themselves is illustrated here by one of their carved food storehouses, on exhibition in the American Museum of Natural History

OTHER PUBLICATIONS ON Peoples of the World

Order any of these items from Man and Nature Publications, The American Museum of Natural History, Central Park West at 79th Street, New York 24, New York. They are all published by the American Museum

PEOPLES OF THE PHILIPPINES. By A. L. KROEBER. *244 pages, 50 illustrations. Cloth bound. Second edition, revised. 1943. Price, $1.00; postage, 7 cents.*

This comprehensive handbook on a region that has become increasingly important in recent years should prove useful to men in the service and to students of anthropology, as well as to the casual reader. It presents an interesting account of the racial and cultural background of the islands and discusses the art, occupations, and religion of the natives. It is a valuable aid to the visitor in the Philippine section of the Museum, whose collections provide illustrations for many of the subjects presented.

THE INDIANS OF MANHATTAN ISLAND AND VICINITY. By ALANSON SKINNER. *64 pages, 27 illustrations. Paper bound. Fifth edition. 1932. Price, 20 cents; postage, 3 cents.*

Few subjects make a more forceful appeal to the student, historian, or even the general reader, than the native Americans who occupied what is now Greater New York. Yet it is very difficult to obtain information on them, for the few accounts which the Colonists left us are in tomes that are rare and difficult of access. This booklet briefly supplies the available information, discussing the life of the natives, their costume, religion, and archaeology.

PEOPLES OF THE PACIFIC. By HARRY L. SHAPIRO. *15 pages, 41 illustrations. Paper bound. 1945. Price, 25 cents; postage, 3 cents.*

This booklet serves to introduce the reader to a wide variety of types of people and their equally diverse and interesting cultures. It is profusely illustrated with beautiful photographs and has an excellent series of maps showing the waves of migration that populated the various sections of the Pacific.

INDIANS OF THE NORTHWEST COAST. By PLINY EARLE GODDARD. *175 pages, 103 illustrations. Cloth bound. Second edition. 1934. Price, $1.00; postage, 7 cents.*

This plainly written account relating to the work and exhibits of the Northwest Coast Indians Hall in the American Museum is valuable not only to the visitor wishing additional information but also to anyone interested in the Indians of this area. It discusses the topography and climate of the territory along the coast from the Columbia River in Washington to southern Alaska, as well as the customs, religion, and art of its inhabitants, expert workers in wood and carvers of totem poles.

NORTH AMERICAN INDIANS OF THE PLAINS. By CLARK WISSLER. *172 pages, 64 illustrations. Cloth bound. Third edition. 1941. Price, $1.00; postage, 7 cents.*

This well illustrated and clearly written handbook is a summary of the facts and interpretations of the culture of the Plains Indians. It serves as a guide to the American Museum's collections and will give the visitor a broader understanding of the materials on display. Further, it acquaints the student and general reader with many of the basic points in the study of this North American Indian culture, including marriage, social and political organizations, and language.

INDIANS OF THE SOUTHWEST. By PLINY EARLE GODDARD. *205 pages, 71 illustrations. Cloth bound. Fourth edition. 1931. Price, $1.00; postage, 7 cents.*

This book will be useful not only to the Museum visitor who desires more information about the subjects illustrated by the collections in the Hall of Southwest Indians, but also to the student of American history and culture. It offers a review of the facts concerning both the prehistoric and historic natives of our Southwest. Among the subjects treated are the Spanish conquest, the Pueblo and Village Dwellers, the nomadic peoples, cliff dwellers, native weaving, the potter's art, and the Hopi Snake-Dance and other ceremonies.

A WORLD FULL OF PEOPLE

THE FACTS OF POPULATION

By HARRY L. SHAPIRO

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THE AMERICAN MUSEUM OF NATURAL HISTORY

A World full of people

By HARRY L. SHAPIRO*
Chairman of the Department of Anthropology, The American Museum of Natural History

The facts of population are vital to every nation and to the international adjustments of the world. Here the basic principles and their significance are discussed in non-technical language

For who can count the multitude of men?
They are like grains of sand.
And who can know their diverse nature and condition,
From the most base to the most exalted?

PEOPLE are the most valuable of natural resources—and the most universal. Perhaps this very ubiquity, together with mankind's propensity to replenish itself with little or no encouragement, accounts for the tendency in many quarters to take population for granted. Indeed, it is probably fair to say that the existence of any problem in this connection would have seemed novel a few centuries ago. If any problem existed then, it was apt to be merely one of stemming the flood of mankind that threatened the available means of subsistence.

We have, however, become aware in recent times that there is more to population than its mere size or its growth, important as these are in a national economy. Population, we now recognize, has a complex structure, with a dynamic balance between the component elements. Alterations in one of these elements, can lead to significant changes in the whole. But more than these quantitative aspects of numbers and rates, population has a qualitative side. Two populations of equal size and of similar age structure may yet be vastly different in biological fitness. This is a phase of population much less known or understood, but obviously one of the utmost importance. To study the behavior of aggregates of people, how they maintain their size, why they increase or decline; to analyze such aggregates into their significant elements and to determine their mutual adjustments; to ascertain if such aggregates are improving or degenerating in quality —these are the aims of the biology of population. It is a subject of the greatest practicality for the welfare of a nation.

A population is the total number of individuals who may be embraced within a given classification. Thus we may speak of a school population, the population of New York City, the male population, or the population of the United States. Statistically considered, these populations may be described by various mathematical devices, and, when chronology or comparison with similar groups is added, we may deduce from such mathematical summations certain trends and tendencies. Because all the units or subdivisions of a nation are influenced far more by each other than any one is by similar units in other nations; because intermixture is more common within national boundaries than across them; because the national destiny combines all the subdivisions into a kind of biological as well as cultural, political or economic entity, we have come to think of the total national population as a biological expression susceptible to scientific study and analysis.

I have frequently speculated a little on the origin and evolution of our

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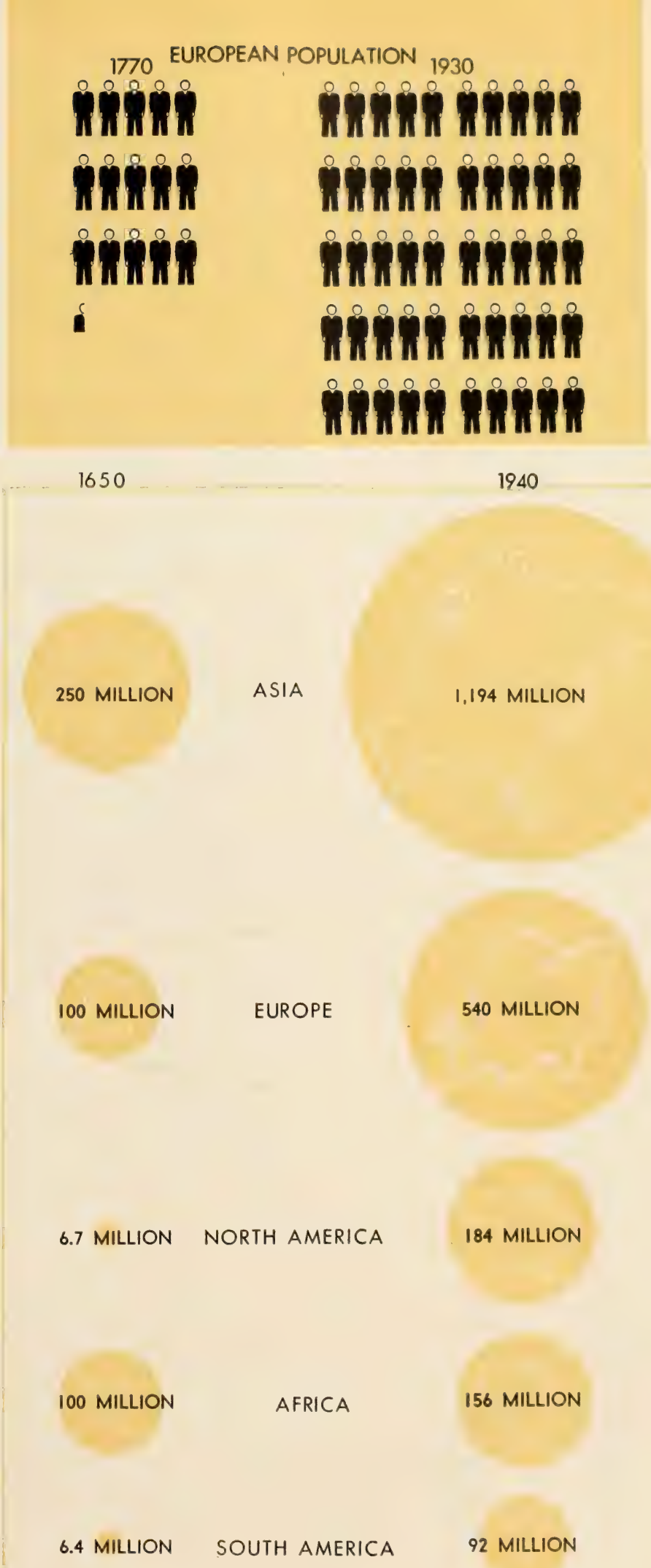
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He has done field work in the West Indies, our own Southwest, China, Japan, and Alaska, and has been on a number of expeditions to the Pacific, particularly to Polynesia. Dr. Shapiro's particular interest is physical anthropology, and he has done much research work in this field and on such related subjects as race mixture, population, etc. His publications include *Heritage of the Bounty, Migration and Environment,* and numerous articles and papers, both scientific and popular. He is active in several scientific societies.

Since 1942 Dr. Shapiro has been Chairman of the Department of Anthropology of the American Museum, where he has worked since 1926. He is also Professor of Anthropology at Columbia University and Associate on the Staff of the Bishop Museum in Honolulu.—ED.

RAPID GROWTH of population due to in-
strial development, lowered death rate, and
e development of resources in the New
orld

interest in the biology of population, and it seems to me that much of it has been stimulated by the accumulation of data provided by the census. Before the notion of census taking became an established function of national governments, little if any attention was directed toward the study of population as population. What enumerations were in existence were outgrowths of other concerns. Tax lists had to be drawn up, or man power resources for military uses had to be mapped. Enumerations of people also had value for the church and were significant for various political and economic purposes. But these counts were never primarily instituted for biological reasons and were rarely employed for such ends. Although they go far back in recorded history, they were with few exceptions, desultory and unsystematic. Not until fairly recent times did the notion become established that periodic and systematic enumerations of the population are valuable and necessary enough to warrant their being a fixed function of the government. The earliest official census, as distinct from estimates, seems to have been initiated in New France in North America and was continued there from 1665 to 1754. The United States was among the first of modern nations to establish, in 1790, a regular census repeated at fixed intervals. Its purpose was primarily political, since it was designed to serve as a basis for representation in Congress. Great Britain began periodic enumerations in 1801; and by the end of the nineteenth century, the economic and political necessity of census taking was recognized in most civilized countries in the world. The necessary organization, however, for an accurate census in a large country still proves a stumbling block for many governments, with the result that even official national censuses vary widely in their reliability from country to country. But whatever the origin of the census



GROWTH OF POPULATION BY CONTINENTS. ote that the increase has been much greater some continents than in others and that e distribution of population throughout the orld is quite different than it was a few nturies ago

may have been—political, economic or military,—the study of population problems proved to be one of its unforeseen and most valuable by-products.

Since the first censuses provided little more than total counts, the pioneer students were restricted, by the very data available, to the problem of the total growth of national populations. It happened, however, that the trends revealed by these initial enumerations were startling enough to warrant serious thought. As early as 1755 Benjamin Franklin was commenting that the population of the United States was doubling every 25 years, and by the end of the eighteenth century Malthus already had enough available data to be impressed by the dangers of a population growing beyond its means of subsistence. How rapidly various European nations were growing may be seen by comparing Europe's population in 1770 and 1930. In 1770 it was 152,500,000; 160 years later it had increased to about 500,000,000—something like 3 times. This remarkable expansion seems to have begun in Western Europe and to have gradually spread throughout the continent. In America the rate of growth was even more rapid than this, as it also was in the British colonies in New Zealand and Australia.

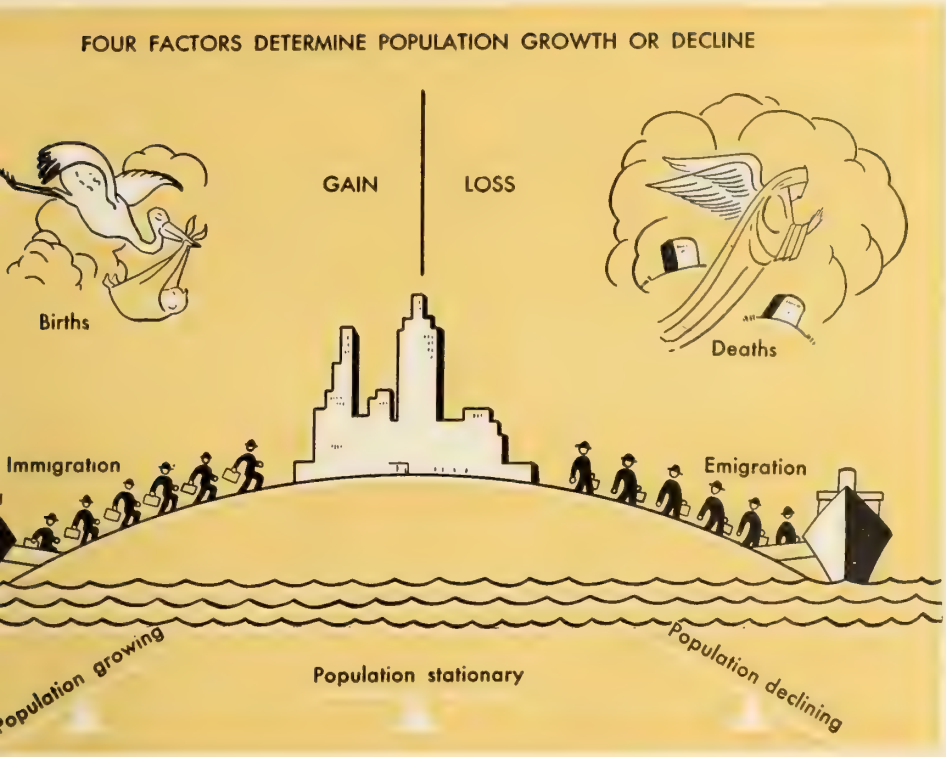
The phenomenon was so widespread and so decisive that at first expansion was assumed to be the natural condition of all populations, and alarm was frequently expressed for a future in which a world bursting with people would find its means of subsistence inadequate to support them. We now know that this increase was merely one phase of the world's population history and that expansions on this scale had never occurred before. Indeed, a little arithmetic demonstrates how unlikely it is that populations in the past have grown at a rate anywhere near their full reproductive possibilities. If, for example, reproduction were uncontrolled, a woman could give birth to 5 or 6 children betwen her 17th and 27th year. If 4 of the children survived and reproduced in their turn at the same rate, the population would double every 27 years. But this is not the highest rate possible by any means. If a woman survived to her 35th year, she could easily bear 8 or 9 children. With only 6 offspring surviving, the population would triple every 35 years. Thus a single couple reproducing at the first rate would yield in 540 years, 2,097,000 descendants, and at the second 45,956,000. In 1080 years the respective number of descendants from one husband and wife would reach 2199 billion and 1,656,000 billion. Obviously, then, mankind has not been increasing at anywhere near its full potential. And the acceleration in recent centuries cannot have been going on for very long. If we project backward the modern population of Europe, reducing it by the same rate that it has increased over the past 160 years, we would find ourselves in an empty Europe at the beginning of the Christian era.

When we recall that man is estimated to have an antiquity of about one million years, it is obvious that he has neither increased steadily nor at his full capacity. Over much of this period the human population must have remained static or even retrogressed. Although statistical evidence of this nature does not exist for mankind's early history, we have some fragmentary evidence to prove that populations are not forever expanding.

Japan, for instance, had a population of 28.1 millions in 1721, and 135 years later her population was roughly the same (28.9 millions). Spain, in the seventeenth century, had passed beyond one growth phase and was in a state of decline, a circumstance rarely mentioned in connection with her political decline and her colonial policies.

Why is it then that populations increase, decrease, or remain static? There are various reasons given, but let us first examine the direct mechanism by which the process itself is controlled. There are four functions whose mutual adjustments determine the curve of a population. These are birth rate, death rate, immigration, and emigration. By the rates of these and by these alone is the size of a population determined. The differential between birth rate and death rate





gives us the natural increase or decrease—the amount by which a population, by the success or failure of its own efforts, is adding to its numbers or losing them. Ordinarily birth rate and death rate alone are the decisive factors, but under certain circumstances the displacement of population from one country to another may strengthen the national trend of a population or counteract it. Immigration to the United States during most of its history was a significantly positive contribution to its remarkable growth. Ireland during the famine years was unable to replace by its own natural increase the losses suffered by emigration. France in recent years has sought to redress her unfavorable balance betwen births and deaths by permitting the immigration of Italians and Poles. But in most countries, and during most of the time, the balance of births and deaths determines the issue.

Natural increase is achieved when the birth rate surpasses the death rate, and the greater the difference the larger the increase. But birth rate need not be increased to attain this favorable balance, it may be accomplished by a decline in the death rate. Where both rates are changing the natural increase will be proportional to the relationship between them. During the past century the birth rate of western Europe was dropping steadily, but the natural increase was maintained because the death rate was also dropping and in some cases more rapidly than the birth rate. Since the drop in death rate has slowed down and the drop in the birth rate threatens to approach it, the natural increase is shrinking away. It is apparent, therefore, that an explanation of why populations increase or decrease must be based on the factors that govern not only the birth rate but also the death rate and the balance between the two.

Among the variables that one might expect to be most effective in determining differences in birth rate is innate fertility. We are so accustomed to having the high birth rates of the Japanese or the Russians or the Southeast Europeans contrasted with the dwindling families of the French, English, and Americans that almost insensibly we come to assume a difference in fertility. Similarly we are apt to attribute a greater power of reproduction to primitive people than to the highly civilized. Some authorities, however, deny that any real distinctions can be drawn between the various races or peoples of the earth in this respect. They maintain that unhampered reproductive rates are approximately the same for all mankind, somewhere between 40 and 50 per thousand, and that whatever deviations occur are attributable to inhibiting factors. For all practical purposes, according to this view, we may neglect any possible variation in innate fertility and speak only of limiting circumstances. The following chart, based on figures published by Raymond Pearl, supports this contention, but it should be stressed that the available data are by no means adequate for a universal generalization. Sterility, however, in so far as it lowers the average fertility of a population does seem to occur more frequently in highly civilized societies than in primitive ones.

Leaving aside therefore the question of any inherent differences in reproductive powers, there are two principal sets of limiting influences on birth rates. One is social and long term, the other is catastrophic and short-lived. A study of primitive as well as civilized sex customs reveals a diversified series of habits and rites that limit in varying degree the natural fertility. Sexual taboos of diverse descriptions, for example, are commonly practiced among primitive people. Sexual intercourse may be forbidden before ceremonial occasions, before battle, for ritual reasons, and for varying periods in connection with menstruation. In extreme forms, a woman may actually be excluded from the possibility of reproduction during half her child-bearing period. The custom among certain primitive







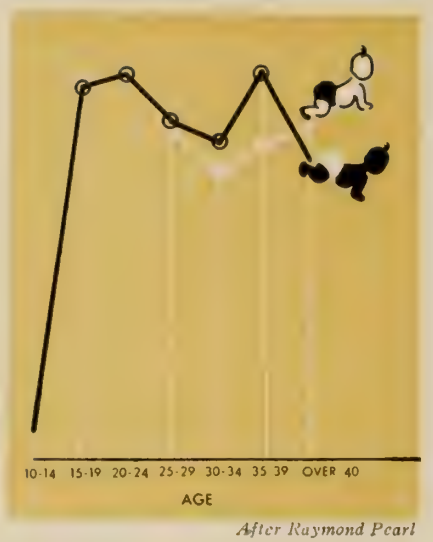
women of nursing children for an extended time tends to reduce the chances of conception, and in fact the practice is deliberate with many of them who desire to keep their offspring at a minimum. It has been reported that some primitive groups who cultivate this device keep their children down to 4 or 5 per woman.

Abortion is by no means universally accepted, of course, as a method of birth control; nevertheless it is commonly practiced in many societies, our own not excepted. How effective or how extensive a method it is we do not know, since accurate information is lacking. Certainly in most primitive societies knowledge of it is widely disseminated, and inquiry readily elicits specific details of procedure as though recourse to it were frequent enough. Estimates for a city such as New York run into colossal figures. One estimate suggests that as many conceptions terminate in abortions as in live births. There can be little doubt that this method of limiting births is one of the most significant in human history.

Another method of reducing the population if not the actual birth rate is by infanticide. This resource is to our minds a revolting practice, yet in certain countries it has been adopted and has received social approval or at least tacit tolerance. It is apt to occur where the pressure of population has become a serious problem. In Tahiti, for example, Captain Cook found the natives openly abandoning female children to exposure and death. The teeming population confined within its narrow island presumably could not expand further and the excess had to perish. Those who doubt Malthus have here an object lesson on the reality of population pressure. China, too, has countenanced female infanticide, and in times of stress its practice increases. So common a thing is it in China that its profound results may be read in the marked excess of males over females ranging from 10% to 50%.

Less direct than these is the effect of various other by-products of social custom. Among them I might mention the increasing age at marriage which, at least until very recently, was evident in highly civilized societies. Economic causes are generally assigned to the tendency to delay marriage among us, but in at least one primitive group with which I am familiar this delay arises from a gerontocracy where the old men are dominant and pre-empt most of the young maidens for themselves, leaving the young men to make the best they can of the old ones or wait for their turn with advancing years. The tendency to delay marriage, other things being equal, results in smaller families.

Concubinage, which one might expect to enhance the birth rate, is said on the contrary, to depress it, since



After Raymond Pearl

▲ THE FERTILITY OF NEGRO AND WHITE WOMEN appears to be similar. The chart shows mean pregnancy per 100 ovulations in women who married only once, had no gynecological disease, and did not use contraceptives

a large number of women are removed from the full exercise of their reproductive possibilities. Women under this system are individually unlikely to have as many children as they would if married to one man, in spite of the impressive totals of offspring that a sole male under such a system may pile up. Similarly large scale prostitution has the same consequences but for a different reason or reasons, one of which is the prevalence of social diseases among the practitioners of this profession. But social disease apart from its existence among prostitutes is also a very significant factor in reducing the birth rate in the general population. This alone was responsible in large measure for the rapid depopulation suffered by Polynesia in the nineteenth century. Let me cite a single instance. The Marquesans at the time of Cook's visit toward the end of the eighteenth century, possessed a population estimated at around 100,000. In 1920 there were about 1600 natives left—less than 1/50th. A survey I made there ten years ago, disclosed a large number of sterile marriages and a high prevalence of miscarriages. Gonorrhea and syphilis were rife. The prospects looked very bleak indeed that this handful of once magnificent Polynesians could long survive. About 15 years ago, however, one of the government physicians began to combat social diseases in a few localities, and in a relatively short time the birth records began to show a remarkable increase. For the first time in over a century a favorable balance was established precisely in the localities where modern medical treatment had been administered.

It has frequently been suggested that urbanization, with its attendant nervous tensions, may be one of the causes of sterility and reduced reproductive capacity. If it is, we cannot assess its role in the complex of factors which are operating toward this result. One of New York's most distinguished gynecologists once told me that he was able in a fair proportion of sterility cases to achieve cures by prescribing rest and travel.

Perhaps the most effective curb on the birth rate is the various techniques of contraception. The idea of contraception is a very old one. It was known in antiquity. But only in recent times has its practice become almost universal in some countries and in certain classes in most civilized societies. Probably no other single factor has been so effective in cutting down the birth rate. Certainly the present drop in birth rate coincides with the adoption of contraception, and this rate is lowest where contraception is most widely used and highest where it is unknown.

In the long run, the catastrophic checks on birth rate are less potent than those already mentioned. Their immediate influence may be more drastic, but, unless a population is already in decay or sharply reduced in number, recovery from them is fairly rapid. Thus famine, which has swept over China and India repeatedly, carrying off millions to death and cutting back sharply the birth rate, seems to have affected but little the general reproductive rate. It has been calculated that between 108 B.C. and 1911 A.D. China was subjected to 1828 famines, or almost one a year. Britain between 10 A.D. and 1846 suffered 201 famines, or 1 every 9

years. India endured 34 between 1769 and 1878, or 1 every 3 years. While these disasters may temporarily reduce the birth rate, they seem to have no permanent or long enduring consequences on reproductive tendencies. In other words the recuperative ability of a population soon makes up losses suffered from such causes when the short-lived cause itself is removed. Long continued war may also exercise a depressing effect on the birth rate. There has frequently been observed a sharp but temporary rise in birth rate at the initial stages of warfare, but this spurt declines into a lag as war continues, and its consequences extend into the post-war period. In the present conflict, the magnitude of the dislocations are beyond our experience, and it would be hazardous to base predictions on the past. After the last war, however, birth rates adjusted themselves fairly rapidly to the pre-war positions and continued their evolution from that point.

The other component in the equation of natural increase is the death



THE TYPICAL S-SHAPED CURVE of population growth, here represented by France, ows a slow beginning followed by a rapid e and finally a gradual leveling off. The rve for the United States, rising from just der four million in 1790 to 132 million in 40, would show a rising slope that has rcely begun to flatten out

rate. In pre-industrial societies and among most primitive groups, this perhaps more than the birth rate is responsible for the dynamic status of a population. There are exceptions, to be sure, but in general a population not appreciably affected by artificial checks on the birth rate will increase as its death rate drops, and will become static when the death rate approaches the birth rate. In the past, the rise of the death rate through epidemics, famines, war, or disease has been more effective in reducing the rise of a population than fluctuations in the birth rate. Conversely, the amelioration of living conditions, improvement in public health, and advances in medical care permit a rapid increase in population by reducing the death rates. The phenomenal expansion of the population of Europe and, indeed, of the world during the nineteenth century may in large part be attributed to these factors. Only as the birth rate begins to follow suit and to overtake the decline in death rate is a static or declining population once more established. This has already happened in France. It seems about to happen in England and the United States.

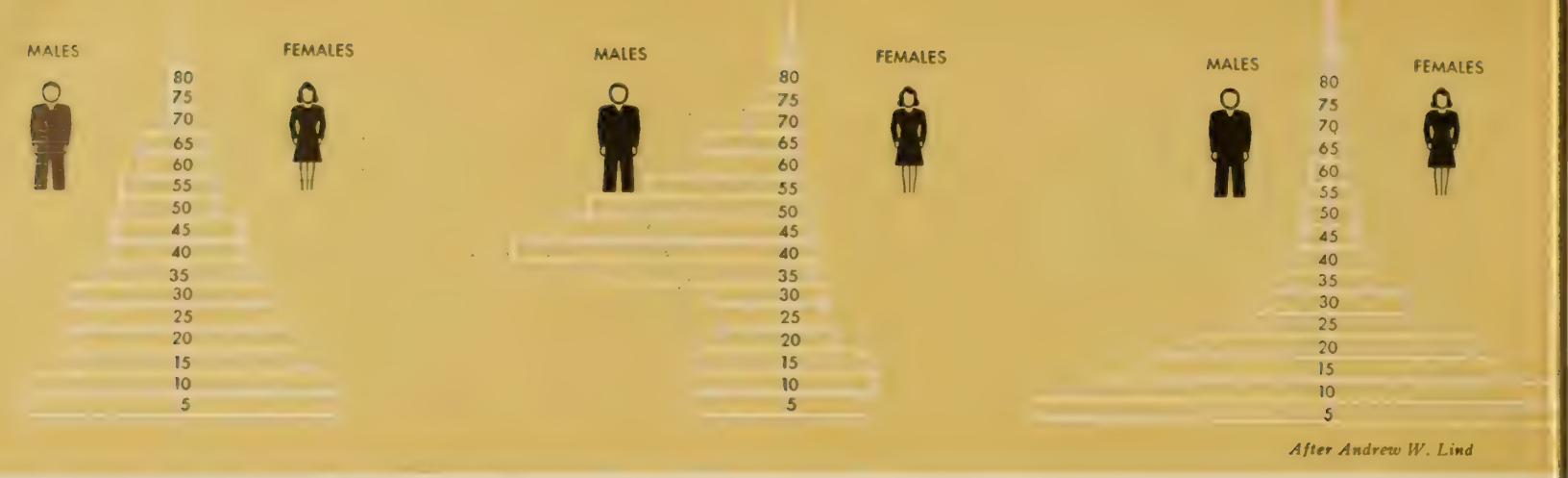
The extraordinary growth which the populations of the world have undergone in the past century or more has stimulated a good deal of speculation on the nature of the phenomenon. Raymond Pearl has reduced it to an equation and has generalized it to the form of a sigmoid or S-shaped curve. Such curves begin by rising slowly, reach their steepest slope at the middle of their spans and then decelerate gradually. Their application to populations is based on the thesis that a population becomes static when it has reached the limit of the current means of subsistence. When these sources of subsistence are increased, growth takes place. But the new spurt is proportional to (a) the absolute amount of growth already achieved and (b) the amount of unutilized or unexhausted means of subsistence. Such curves fit quite well the history of modern populations and have served many students in their predictions on the future size of existing aggregates.

But to describe the phenomenon does not explain it. Corrado Gini has a somewhat anthropomorphic explanation. He considers a population to be something like an organism—that it has a youth, a middle, and an old age. During its vigorous youth it grows rapidly. Then as increasing age makes itself felt, it begins to lose its reproductive force and becomes static or even declines. It would be difficult on this basis to explain the vigor in the ancient loins of China and Italy.

Warren S. Thompson, on the other hand, stresses the importance of environment, by which, I take it, he means agricultural and technological improvements. Looking at the full sweep of man's history, we do see definite increases in the density of population when new procedures or inventions permit the support of larger numbers. Hunting or food-gathering societies are not usually able to maintain a population as large as an agricultural community in the same area. In aboriginal America, the largest concentrations existed precisely where settled agriculture was well organized. Cities and large populations in the Old World first appeared in the rich valleys of the Nile, the Tigris, the Euphrates, and the Indus, where agriculture received its initial development. The remarkable expansion of population that is so striking in recent centuries coincides with the advent of industrialism, the expansion of trade, and the exploitation of the New World. These events have enriched the sources of subsistence and permitted a new growth of population.

To list the total number in a population or even to define its rate of growth does not tell the whole story. A population not only has size; it also has structure. By this I mean that populations are composed of different kinds and categories of people, the numbers and relationships of which vary from time to time and from place to place. If we classify a given population according to sex and age, we can plot the percentage of the population in every category. Normally, the result is a pyramid with the most numerous class where one naturally expects it, in the youngest age at the bottom, and the least numerous among the most aged at the top. Such a pyramid tells us much about the past, present, and future of the population it represents. If the pyramid has a relatively broad base, we may anticipate, other things being equal, a rapidly growing population, since the future reproducers of the populations are to be found in the youngest generations. On the contrary a population barely replacing itself will have a relatively narrow base.

The profiles of the populations of the United States and various western European countries reveal a striking change during the past century. As the death rate has declined, the number in the older age classes has increased. At the same time the base has contracted due to the reduction in birth rate. We see, therefore, a change in the age structure of these populations that has had a profound significance not only on the growth



After Andrew W. Lind

↑ UNDER NORMAL CIRCUMSTANCES there are more young people than old ones in a given population, and the age groups between show a fairly regular decrease in numbers. Note also that the number of males (*left of mid-line*) is approximately equal to the number of females (*right of mid-line*). This diagram shows the total population of the Hawaiian Islands in 1930

↑ BUT WHEN YOUNG and middle aged men without wives or families move into a region, a bulge appears on the male side of the population pyramid. The diagram above shows this in the Chinese population in Hawaii in 1910

↑ WHEN YOUNG PEOPLE predominate in a population, the pyramid has a wide base and thin top, as in the case of the Asiatic-Hawaiian population in 1930. This diagram shows that mixed marriages have been fairly recent and productive, and the children have not had time to grow up

of the population but also on its biological and sociological characteristics. As the senile and old increase, the rest of the population have to shoulder a greater burden, made up of those who not only are non-productive but are also in need of care. The social agencies to tend the chronically ill and the incurable, and the financial obligations to support the superannuated increase at an alarming rate. The number of productive workers to discharge these growing social responsibilities becomes relatively fewer. This in itself might have a ramified series of reactions on the social organization, but how far their effects may be modified by technological advances that make up for the relative loss of workers cannot be easily estimated.

An aging population, or to be more exact a population with an increasing proportion of middle-aged and senile individuals, may influence the social, political, economic, and intellectual orientation of a nation not only directly through its voice in the government but also indirectly by more subtle means. Even though we may not have at hand objective evidence on this possibility, it is a legitimate field of inquiry. One cannot help but wonder whether a young Elizabethan England would have approved of the cautious, elderly appeasers of Chamberlain's England. I do not, of course, wish to imply that the difference between these two eras was simply a matter of the age of their respective leaders. I am aware, moreover, of the complicated background of the pre-war situation. And I know that Mr. Churchill celebrated his 70th birthday just the other day. But is it altogether unreasonable to expect the policies of nations to reflect the age of the policy makers and of the electorate?

Age and sex, however, are not the only components of population. Indeed, the only limit to the breakdowns and the classifications to which a national aggregate may be subjected lies in the records available. Most of them, however, are temporary and ephemeral characteristics of little or no biological importance. Even much of the census information serves no biological ends. It may be valuable, for example, to know the extent of illiteracy by states and other things about the educational status of the populace. Economists may find statistics on home ownership extremely useful. But these data have no bearing on biological structure. Even the age and sex classifications fail to tell us much of the biological quality of the people. Yet it is of paramount interest to know what hereditary differences in quality exist and whether the superior or inferior individuals are increasing more rapidly.

For example, the composition of a population divisible into 3 distinct groups, would undergo changes proportional to the rates of growth of each group. The accompanying diagram indicates the magnitude of change in a hypothetical case within the bounds of probability.

Such changes in the relative strength of diverse components in a population are much more common than we have come to realize, because our data are rarely presented in this form. Yet we may see in the course of the nineteenth century the Scotch drop from 15% to 10% of the combined population of England, Wales, and Scotland. In the United States, immigration and differentials in birth rates changed the population from a predominantly English one to one in which German, Irish, Italian, Polish, and other continental nationalities represent considerable percentages, with a relative if not an absolute loss in the English contingents. It is interesting that this tendency, in force for a century, and one that alarmed certain writers, seems now likely to be reversed to some extent. At present the agricultural south, largely British in origin, is furnishing a disproportionate share of the national increase. The high birth rates of the newer immigrants, formerly viewed with foreboding, have dropped below those of the mountain whites of the South. I cite these figures not because I consider the groups significantly different but to illustrate the possibility of a rapid shift under the influence of persistent trends.

If therefore, a total population may radically change its group composition, is it not possible that its biological quality may also undergo alterations? If the Kallikaks and the Jukes, overburdened with degeneracy, outbreed the Edwardses, may not the qualitative character of the total population suffer? To deny the possibility would be purblind, to affirm the

reality would require, however, more knowledge than we possess. Our measures of quality, however, are still so nebulous and are complicated by so many non-biological factors that I hesitate to accept any conclusions drawn from such inadequate yardsticks.

It is true that the poor are breeding more rapidly than the rich, that the rural sections are supplying the populations for our cities, that the agricultural south is increasing at a higher rate than the agricultural north, that Catholics have larger families than Protestants and Jews. But such differentials can only alter the biological character of a population if they are correlated with inherited, qualitative distinctions. Such correlations based on reliable evidence are lacking. The only trustworthy associations seem to run in family lines and not by groups. This is perhaps the key, as it is in so many group statistical studies. We must consider the individual and not his group.



JUKES

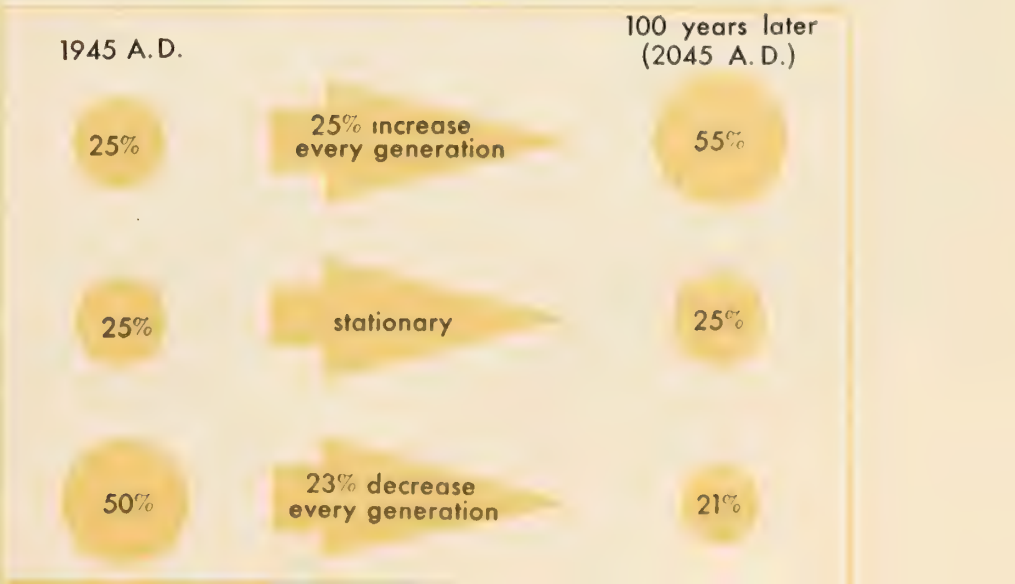


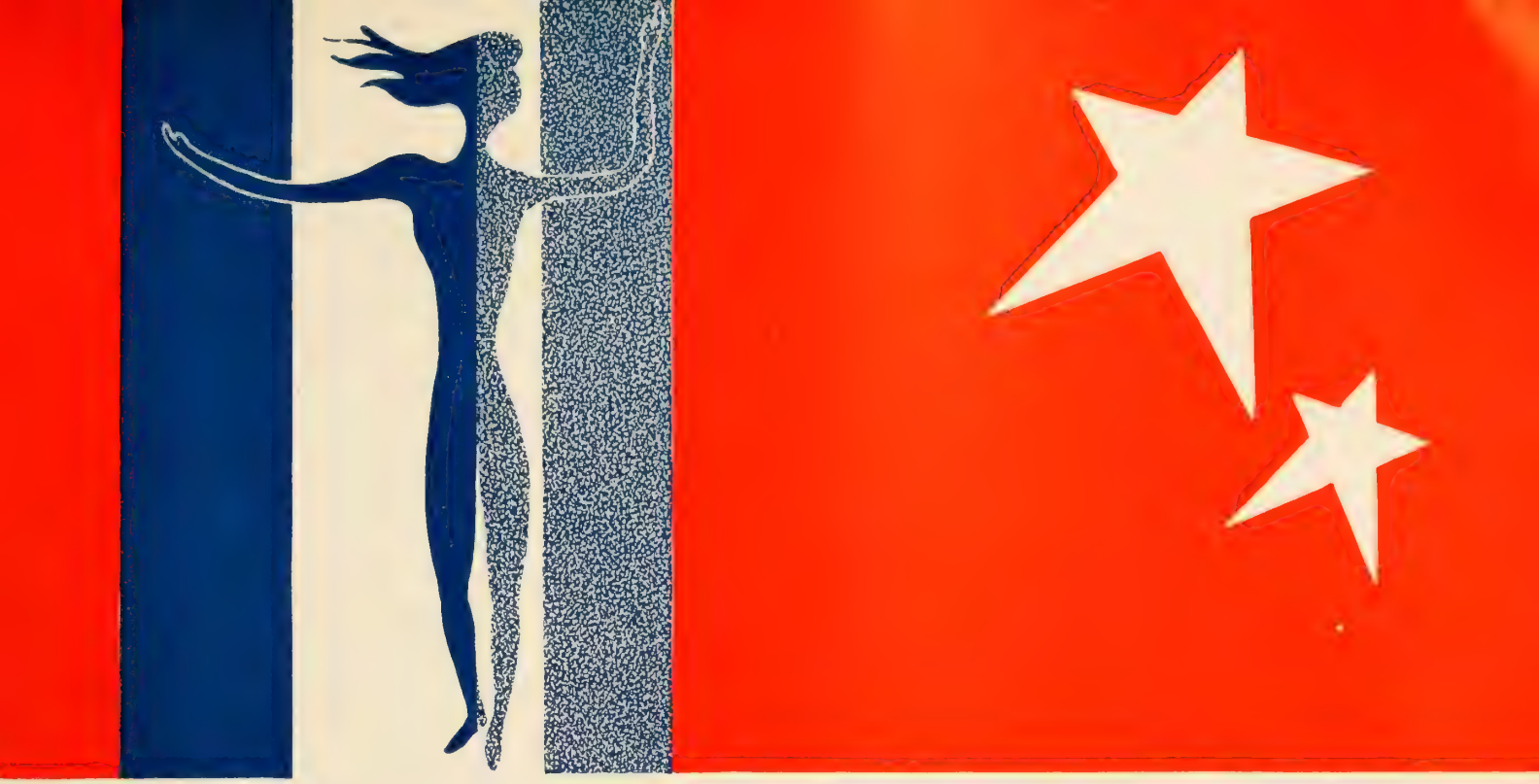
EDWARDSES

	JUKES	EDWARDSES
USEFUL CITIZENS	Socially successful 14%	College graduates 21% Lawyers over 7% Theologists 7% Officers in Army or Navy 5% Men of Letters 4% Doctors 4% Judges 2% Professors 1%
BURDENSOME CITIZENS	Mentally deficient 5% Criminals 6% Paupers 8% Intemperate 9% Illegitimate 14% Prostitutes 18%	No criminals or mentally deficient

A WHEN EXTREME examples are analyzed, it is clear that families differ widely in their contribution to society. The "Jukes" family, embracing 2,094 descendants, have cost the State over $2,000,000. The Edwards family, of whom 1,394 descendants have been traced, have given the nation an impressive number of intellectual leaders. The relative importance of heredity and environment is not evaluated in this analysis

B A POPULATION can change its composition profoundly in a few generations if the various components increase at different rates





AMERICANS

Yesterday, Today, Tomorrow

By Harry L. Shapiro



THE AMERICAN MUSEUM
OF NATURAL HISTORY

No. 126

AMERICANS

Yesterday, Today, Tomorrow

By

HARRY L. SHAPIRO

MAN AND NATURE PUBLICATIONS

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NORMA—the average American girl

SHE IS MODELED from recent measurements of 15,000 women from many parts of the United States and from various walks of life, including series of college students and other thousands of native white Americans. She is slightly heavier yet more "athletic" than her grandmother of 1890 and has lost the shrunken waist induced by tight corsets. As to the beauty of her figure, tastes will vary; fashions change ideals from one generation to the next. Norma is not meant to show what ought to be; she shows what is.

Dr. Robert Latou Dickinson, who drafted the proportions and posture of the figure, has devoted six years with Abram Belskie to the planning and finishing of anatomical, obstetric, and surgical models which might be widely distributed for teaching purposes. In this work, at the New York Academy of Medicine, he has consulted the great anthropologists in person and tapped all the statistics to ensure accuracy in all details. He shows in Norma the average American girl of our day, 18 years of age.

The sculpture has been done by Abram Belskie, member of the National Sculpture Society.

The statue, like that of Norma's "brother" on page 252, is reproduced for the first time in NATURAL HISTORY Magazine through the courtesy of the sculptors and the Cleveland Health Museum, which will take over production of the series.

A.M.N.H. Photo



*Americ*s

Scientific studies reveal that we have changed considerably since the days of our forefathers. The typical American is certainly quite different from what other nations have predicted for us, also perhaps different from what we ourselves have imagined

Most Americans, in conversation with representatives of other nationalities, have probably found themselves discussing what it is that distinguishes the people of the United States and as frequently, no doubt, attempting to define the character of the other nationalities in such a mixed company. In this world of self-conscious nationalism, almost every country has acquired a personality and a type—often enough, a kind of Janus or split personality, one face as the country sees itself and the other as seen by its neighbors.

The British, collectively, in their national self-portraiture, are inclined to emphasize quite naturally the traits they regard as lovable, worthy, gentlemanly, or noble. Their native spokesmen describe them as reserved, sensitive, poetic, devoted to fair-play, fond of sport, inclined to "muddle through," and eminently law-abiding. Foreign and less generous observers are more likely to dwell on their pig-headedness, their snobbishness, their perfidy, and various other less agreeable human traits.

The French, too, take pride in their catalogue of national virtues, which they sometimes imply are uniquely theirs, such as their logic, their intelligence, their thrift, their capacity for passion; while in the hands of their critics, their thrift becomes parsimony and their passion a form of immorality and lack of restraint.

We Americans, also, have a fa-

—Yesterday, Today, Tomorrow

vorite chromo of ourselves that we like to hang in the family parlor. We picture ourselves as idealistic, honest to the point of being easy marks for our devious neighbors, generous, hospitable, friendly, inventive, efficient, competitive, and progressive. Many Europeans look darkly at this picture and take on their own account a few candid camera shots that are as flattering as passport photographs, revealing us as dollar-chasing Shylocks; insensitive to culture, meddlesome, flippant, boastful, and preaching; gangsters who are ridden by a mania for speed, gadgets, and law-breaking.

Although these characterizations are stereotypes, which at their best are merely acute generalizations and at their worst malicious and inaccurate, they are symptomatic of the trends of national differentiation that arise from differences in history, environment, and culture. Even if we cannot measure it objectively, the reality of national patterns of character structure is patent enough from experience.

An American, even of the purest English descent, who reverses the trail of his ancestors and hopefully transplants himself in England, is likely to encounter some difficulties in recrossing the line that now divides an Englishman from an American. The experience of some of our most celebrated expatriates illustrates how American Americans have become. Henry James, for all his love of the English and their ways and for all his efforts, never succeeded in passing as an Englishman among Englishmen, although it must be admitted that he sometimes fooled Americans. Sargent and Whistler, utterly different as they were in so many things, always remained Americans as far as the English were concerned, except when they were claimed as ornaments of British painting. Sir Osbert Sitwell recalls that



One American Ideal

ONE IDEAL in the feminine figure is represented by Rosemary Sankey, chosen to epitomize the "high fashion girls" of John Robert Powers. These models, constituting a very uniform physical type, are significant because they are eagerly sought after as dress models and are obviously much admired by the public. In this group, bust, waist, and hip measurements of 34-24-34 are considered close to the ideal. The greatly increased height, the notably wide shoulders and the slender hips of the "high fashion girl" combine to differentiate her from Norma; but these same characteristics may also be regarded as the extreme of a tendency that has been noted to a lesser degree in the average American girl in recent generations.

Miss Sankey herself shows a figure that is further in this direction even than the average "high fashion girl." Her measurements are: shoulder width, 14.9 inches; bust, 33½ inches; waist, 23 inches; and hip width 11¼ inches. She is 5 feet 7 inches tall and weighs 117 pounds.

Photograph by Don Selchow.

when his father commissioned Sargent to paint a conversation piece of the Sitwell family, Lady Londesborough, the maternal grandmother, distinctly disapproved of the choice of Sargent on the grounds that he was an American. I should perhaps add that Sitwell, père, did his best to find an English painter and only settled on Sargent after discarding several English candidates as inadequate.

Personalities, however, although they seem to persist like the smile of the Cheshire cat long after the body has vanished into thin air, do enjoy ordinarily a physical embodiment. Certainly no picture of the American people as a whole can omit this vital component, which, unlike its abstract personality, is much more susceptible to exact description and objective measurement. The existence of a physical type, distinctively American, has for a long time been quite generally accepted both by Americans themselves as well as by foreigners. Indeed, regardless of any scientific support for such an opinion, one would have to be singularly impervious to suggestion to escape sharing it. Hollywood presents us with an inexhaustible parade of "typical American" beauties. Charles Dana Gibson delighted our mothers and our fathers with the apotheosis of the American girl of the 1900's. Lord & Taylor advertises "that American look" as the product of our native soil. And who is not familiar with the lineaments and aspect of Uncle Sam, our national portrait. If our artists, our impresarios, and our copy-writers had failed to convince us, our own observation could not. Americans, visiting Europe before the war, were easy to spot, not only by fellow Americans but also by natives and by those whose business flourished by virtue of their skill in this species of detection. No doubt clothes, manners, and speech contributed to make it relatively easy to distinguish an American from the indigenous population; but frequently enough, recognition was possible even without these adventitious aids.

I have been unable to determine precisely when Americans, or Europeans for that matter, first became aware that there was something that could be called an American physical type. Discussion of a generalized American character, it is true, appears well established by the middle of the eighteenth century. Franklin, for example, speculative as he was on many topics of general interest, held views on this, too. And even earlier one can find such colonial worthies as Colonel Byrd and the Mathers speaking of local manners and behavior as if they already recognized an American pattern, although not designating it in such broad terms. Certainly, by the end of the eighteenth century, interest in the American character, stimulated by the Revolution and the birth of a new nation, occupied the attention of almost every writer who ventured to discuss and describe the United States.

English visitors were particularly aware of our national personality; with few exceptions they found it unattractive and, of course, inferior to their own. Isaac Weld, Mrs. Trollope, Charles Dickens, and Captain Hall, among a host of other English travelers in the nineteenth century, standardized the excrescences of the portrait. In fact, one is somewhat amazed in reading this literature to reflect how analogous it is with the recent writing on Russia. The United States at the end of the eighteenth century and the early nineteenth represented to the Europe of that day a reprehensible and dangerously radical departure from political decorum. European and particularly English observers loved to dwell on the less attractive side of life in America. Democracy was not what it was cracked up to be. The democrats chewed tobacco; they entered into conversation without waiting the formality of an introduction. As servants they were forward and insisted on regarding themselves as good as their masters. Their offspring were independent and pushing. Democracy was noisy, aggressive, and lacked the refinements of traditional societies. Table manners were appalling and public conduct beyond words. Public and private conveniences, roads, carriages, trains, hotels—all were inferior to their European counterparts and uncomfortable.

Life, manners, and character altogether were so unsatisfactory that they seemed to take up all the attention, and little or nothing was left over for observation of the physical traits of Americans. When comments were made, they were apt to be disparaging. American girls had poorer color than the rosy-cheeked English girl. Americans had poor teeth, or the women were pretty enough as girls but faded quickly. But the American as an emerging subtype, neither English nor Dutch nor French but American, was slow in being recognized, or at least less obtrusive to foreign visitors than the facets of our national behavior. Crèvecoeur, however, a sympathetic French observer of American life in the latter half of the eighteenth century, commented enthusiastically on most aspects of it and with reference to Americans as a people wrote "here individuals of all nations are melted into a new race of men, whose labors and posterity will one day cause great changes in the world." This is one of the earliest references I have been able to find to the famous assimilation process that was to become widely known as the "melting pot."

Americans themselves, no less than Europeans, commented little, if at all, on the existence of an emergent physical divergence from their European forebears until the latter part of the eighteenth century when political events were beginning to weld a sense of nationality among the scattered colonies along the seaboard and to stimulate a feeling among Americans that they were a distinct people. Since exact evidence is lacking and contemporary observations are scanty, we cannot, in fact, be positive that there was in colonial times any obvious deviation among the colonials from the physical standards of their ancestors. Perhaps one of the reasons for this inattention sprang from the circumstance that for well over a century after the first settlements, the colonists were accustomed to think of themselves not as Americans but as Englishmen, Hollanders, Germans, or Frenchmen. They had come to the New World as Europeans, bringing with them not only the biological heritage but also the manners, customs, and ideas of their native lands. So conscious were they of their Old World origins and ties that even after a century of residence in the New World, they continued to call themselves Englishmen, Frenchmen, Swedes, or Hollanders. Their settlements were named New England, New Amsterdam, New Sweden, Nova Scotia, or, in loyalty to their sovereigns, Virginia, Carolina, Maryland, and Georgia. They fashioned their houses after models familiar in the countryside from which they came. They reproduced, as far as the

new environment permitted, the life they knew in the old country; with such success in the Pennsylvania Dutch country that an eighteenth century traveler was amazed at the fidelity of the reproduction. Even after generation had succeeded generation, a native Virginian or New Englander of colonial times might still speak of "going home" when he merely meant a visit to England.

One of the earliest commentaries on the physical characteristics of Americans seems to have occurred in the latter part of the eighteenth century. The principals were our own Thomas Jefferson and the Abbé Raynal, a French popularizer and encyclopedist. Raynal, adapting Buffon's ideas on American fauna, had applied them specifically to the Europeans transplanted to the New World. The thesis was briefly this. Buffon, the grand panjandrum of French scientific circles, had come to the conclusion that American animals were smaller and inferior to their European equivalents. In addition, he cited reports widely current in Europe that domestic animals brought to America rapidly degenerated. It was firmly believed that not only did cows, horses, pigs, and other barnyard denizens become smaller and runtier, but they fell off in production. Cows in America, it was said, produced milk in quarts where in Europe they yielded in gallons. Speaking of the indigenous tribes of America, Buffon wrote:

"The American Savage, it is true, is little less in stature than other men, yet that is not sufficient to form an exception to the general remark—that all animated nature is comparatively diminutive in the new continent. In the savage, the organs of generation are small and feeble; he has no hair, no beard, no ardour for the female; though more nimble than the European, from being habituated to running, he is not so strong; possessed of less sensibility, yet he is more timid and dastardly; he has no vivacity, no activity of soul, and that of the body is less a voluntary exercise than a necessary action occasioned by want. Satisfy his hunger and thirst, and you annihilate the active principle of all his motions; and he will remain for days together in a state of stupid inaction."

To account for this degeneracy, Buffon spoke like a true eighteenth century naturalist and attributed it to the American environment and in particular to the fact that America, having only recently emerged from the sea, possessed a "watery climate" which was less favorable as compared with the presumably drier and more invigorating climate of Europe.

This then was the hypothesis that Raynal took up and expanded to include all the human fauna of America, aboriginal and transplanted. At this point, Thomas Jefferson took up the cudgels and belabored Raynal and Buffon with tables of comparative weights that left no shred of comfort to his opponents. In instance after instance Jefferson demonstrated that the American species were distinctly heavier and that, if weight alone were any criterion of quality, there could be no doubt that the superior article was to be found over here. Whether our climate were watery or not, Buffon and Raynal were certainly all wet.

Although this footnote in our history is amusing in view of what has actually happened to the physical development of our population, it throws no light on eighteenth century opinion on the progressive development of a native type except in so far as it was alleged to be a degenerating one. Local differentiation to some extent was recognized, to be sure, and the Yankee as contrasted with the Southerner was becoming a stock figure; but the distinctions were based largely on manners, attitudes, and way of life, although physical differences seem not to have been completely ignored. In this period, too, the frontiersman began to crystallize as a physical type, although the characteristics that marked him are not always consistent or explicit. It is, however, only after the Revolution that one becomes aware of a growing tendency of Americans to think of themselves as a nation—as Americans, despite the tendency of the Virginian or the New Englander to cling to a local allegiance. This increasing sense of a common nationality found expression in the opening years of the nineteenth century in the discovery of a representative type in Uncle Sam, who rapidly gained a national personification that has continued to the present day.

How much truth there was in Uncle Sam is a matter of conjecture. Tall, lean, long-legged figures seem to have become frequent enough among Americans of this period to have attracted comment as symptomatic of a national trend, but it is unlikely that Uncle Sam approximated anything like an average of the total population at the time of his creation. Perhaps, like a caricature, he owes his being to a deliberate exaggeration of an actual but subtle tendency in the population. He was, in other words a type of some frequency in the general population but not an average, and his selection to represent the nation rested on the fact that as a type he was to be found more characteristically here than in other countries.

Since Uncle Sam was not the *average* American of 1800 (at least we have no evidence that he was), it would be profitless to compare him with the American of today in an effort to determine whether or not the American people have altered appreciably in the course of 150 years. We have, fortunately, for our contemporary population the kind of data that was completely absent in 1800. Although the material now available falls short of perfection, it is extensive enough to give us an excellent idea of the average dimensions and proportions of the American man and woman of our own times,—the kind of summation impossible for earlier periods in our national evolution. The principal sources from which the reconstruction of the average American male and female may be drawn are varied. They include the information made available by a survey of a couple of million men in the army during the first World War, special studies of the old American stock, series of college men and women from various parts of the country, a sample measured at the recent World's Fair in Chicago, insurance company records, and extensive data obtained by the Bureau of Home Economics on 15,000 American women who were measured in detail to provide more accurate dimensions and proportions for sizing women's ready-made garments.

Recently, a distinguished team of co-workers, Dr. Robert L. Dickinson and the well-known sculptor, Mr. Abram Belskie, who have collaborated in the past to produce a unique series of anatomical models, turned their talents to creating models of the average American male and female in the full flush of early maturity. Their results, embodied in the two handsome figures sculptured at one-half life size, which are reproduced on accompany-



A.M.N.H. photo

NORMA'S TWENTY-YEAR-OLD "BROTHER" is also a product of Dr. Dickinson's studies and was modeled by Abram Belskie. Both of these statues and the measurements on which our knowledge of physical trends is based, leave little doubt that the figure is improving esthetically

ing pages, translate into three dimensions a composite of the available data. The female figure, named "Norma" appropriately enough, represents the norm or average American woman of 18 to 20 years of age. "Normman," her male counterpart, is modeled on averages for 20-year-old males.

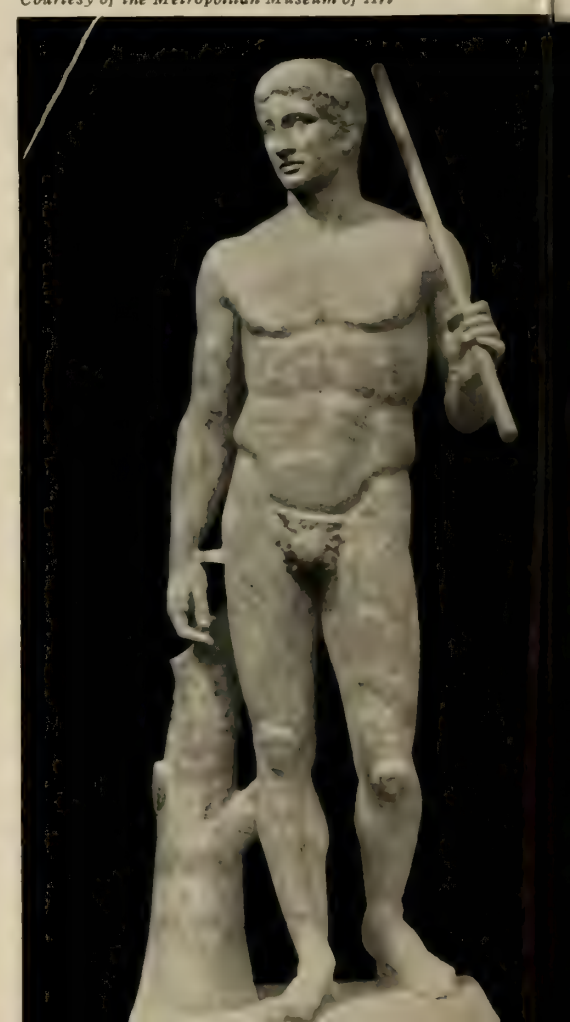
The effect these figures convey is one of a body that is tall, long-legged, and well proportioned, and far more favorably impressive, at least esthetically, than might have been anticipated from casual observation. In fact, Norma and Normman, although they were designed to conform with the average adult before the onset of the ravages of age, exhibit a harmony of proportion that seems far indeed from the usual or the average. One might well look at a multitude of young men and women before finding an approximation to these normal standards. We have to do here then with apparent paradoxes. Let us state it this way: the average American figure approaches a kind of perfection of bodily form and proportion; the average is excessively rare.

Ordinarily, when we think of perfection, or the approach to it, we place it at one extreme of a curve of frequency, whose middle range or average is equivalent to mediocrity. Virtuosity, for example, is never at the middle of a curve of frequency. The most skilled musicians, the finest painters, the loftiest intelligences are rare and exceptional, never average for any population. Why, then, should the average bodily proportions strike us as a form of perfection; and if it is average, why is it rare? There are, of course, esthetic and anatomical considerations involved here, but I shall confine myself to a statistical explanation. The extremes of any single physical character are generally statistically rare, whereas the average is frequent. The middle ranges of stature are most commonly seen, the average weights most often recorded, the mean of a bodily proportion is the most usual.

All these averages are in themselves individually pleasing, and they are common and usual, observed singly. A very fat lady and a very thin one are both rated ordinarily as less attractive than one of more average weight. Obviously, then, if the averages of all traits are brought together in one individual, such a person is bound to agree with the standard not only for one but for all the characters that define bodily proportion. But the combination of so many averages in one person is rare and unusual. One may have an average stature but be far above normal in weight; another may conform to the average for height and weight but possess hips or shoulders that fail to achieve the mean. Thus it comes about that the

DORYPHORUS, THE SPEAR THROWER: a Greek ideal of about 400 B.C. This figure, 7½ heads high, exhibits a massive torso and well proportioned limbs, combined to give an appearance of power rather than agility or speed

Courtesy of the Metropolitan Museum of Art



average physical type is pleasing but also unusual.

Bodily perfection like any other esthetic ideal is admittedly a matter of taste, a subject that may be dismissed with the phrase, "*de gustibus non est disputandum*," or carried into rarefied levels of sensibility. It is, however, interesting to compare Norma and Normman as created by Dr. Dickinson and Mr. Belskie out of the realities of living Americans with the ideal figures conceived by the classic masters according to artistic canons of bodily proportion. The archaic Greeks, bound by the traditions of Crete and Egypt, deliberately carved statues with exaggerated and often unlife-like proportions, and it is not until the fifth century B. C. that we find the classic figure fully developed. The sculptors of this period strove to create a harmonious and ideal body based on the proportions of living men and women but brought to a higher perfection of abstract beauty. It is an idealization rather than a copy of a living model. One of the most celebrated sculptures of this period is the Doryphorus by Polycletus (about 440 B.C.) which, because its proportions were regarded as approximating perfection, was known as the Canon. The height of Doryphorus is 7½ heads (measured from the base of the chin to the crown of the head). Compared with it, the average American male is much taller, (though still about 7½ heads high), and much more slender not only in the limbs but also in the torso. Somewhat later Greek sculptors like Lysippus (about 320 B.C.) lengthened their figures to 8 heads, but the solidity of body remains when contrasted with the modern American. The Venus de Milo, also 8 heads high, a proportion that agrees with that of Norma, is, however, much broader in development, with hips that look massive against Norma's relatively slender ones.

Since classic sculpture represented an ideal and not an average, we are warranted only in concluding that our averages of today are deficient judged by classic concepts of ideal beauty. Who can tell how far the contemporaries of Pericles were wanting by the same measures of perfection?

But modern notions of bodily harmony have changed. The world of fashion and photography, for example, favors an ideal and a canon distinctly its own. The "high fashion girl," whose elongated and elegant grace we see in the pages of the slick magazines and in the advertisements of high priced garments for women, is eagerly sought after as a dress model and much admired by the public. Her broad shoulders, slender hips, and long legs show off clothes to their best advantage and thus help sell the product she displays. Is she a type that suits the prevailing trend of a fashion that might tomorrow leave her demodé, or does fashion follow her contours because she represents an exaggerated but elegant form of a changing bodily conformation in American women?

That the American woman, no less than the American man, has been changing in physique has been frequently asserted and is well known to clothing manufacturers, who have been obliged to make a number of alterations in their sizing formulae to fit the public. Our elders who have commented, sometimes unsympathetically, on the changes to be seen in the younger generations, may refresh their memories of their own intimate appearance of 50 years ago in the illustrations of Professor Dudley A. Sargent's figures of the average col-

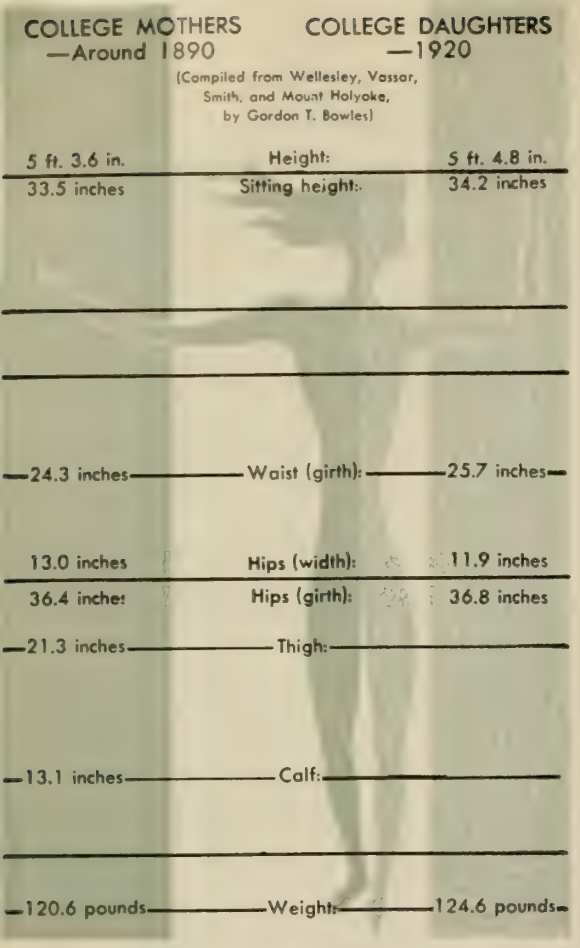


▲ THE AVERAGE young man and woman of the Gay Nineties as portrayed in two figures scientifically constructed by Professor Dudley A. Sargent. Both were shorter than their modern counterparts. The woman also had a narrower waist than her "granddaughter"

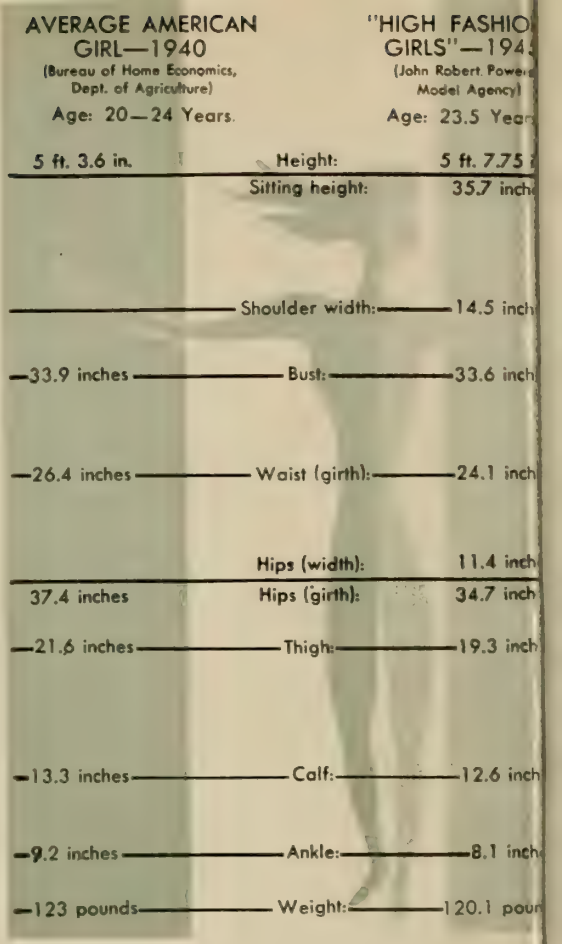
▼ THE EARLY GREEK IDEAL in feminine beauty is seen in the statue of Aphrodite of Cyrene, sculptured in the second century B.C. after a fourth century type

Courtesy of the Metropolitan Museum of Art





THE COLLEGE DAUGHTERS of 1920 were taller and heavier than their mothers but had relatively narrower hips



THE AVERAGE GIRL today is stockier than the College Girl of 1920, but her height is likewise increasing. Her bust measurement exceeds the "high fashion" girl's, but she is four inches shorter

lege man and woman of the gay 90's. These models were constructed from a large series of measurements of Harvard and Radcliffe students and make an illuminating comparison with the "Norma" and "Normman" of 1945. If the Sargent reconstructions are as representative for their day as the Dickinson-Belskie models are for the present generation, there can be no question of the esthetic improvement in the present population. The girl of the 1890's had a constricted waist, the effect no doubt of corsets and the hope of achieving a girth that could be spanned by a man's two hands, if such liberties were thinkable. She seems, moreover, somewhat disproportionate in having legs too heavy for her torso, or, if one prefers, a torso undeveloped for the size of her hips and legs.

We are fortunate in having at our disposal for such a comparison with the past an abundant body of exact evidence that leaves no room for doubt that a marked change has occurred in the physical development of our population. Repeated measurements on the students of various colleges throughout the United States all agree that this generation is considerably and consistently taller than its parents. One of the most extensive series in time covered is the Harvard study, which embraces a continuous record of around 75 years. Dr. Gordon Bowles, who has analyzed these figures with great skill, has been able to demonstrate a remarkable increase in size and an alteration in proportion in Harvard undergraduates as well as in college women in a number of Eastern schools. To indicate the rapidity and magnitude of the change, I shall cite the average statures of Harvard students by decade of birth. Beginning with 1856-65 and continuing by decades up to 1906-15, the average statures are as follows: 5′ 8″, 5′8⅔″, 5′9″, 5′9½″, 5′9⅘″, and 5′10″. Sons compared with fathers increased 1.38 inches in height, gained 10 pounds, developed broader shoulders and narrower hips. College girls compared with their mothers added 4 pounds to their weight and 1.15 inches to their height. They have expanded around the waist by almost an inch and a half (from 24.2 inches to 25.65 inches) and around the hips by less than one-half inch (from 36.35 to 36.8 inches), although the hips have actually decreased in width by an inch. The daughters also seem better developed in other ways too. They have chests that are an inch greater in circumference and are capable of a greater expansion. Their arms are slightly larger in girth, presumably being more muscular.

This is far from being an isolated phenomenon, confined to the college population and restricted to those born in specially favorable circumstances. Neither is it characteristic only of one stock in our national "melting pot." College records from north, south, east, and west, from endowed, expensive schools and from state universities parallel the trends uncovered in the Harvard sample. Growth studies on children repeated on the same population after the lapse of a generation or more disclose the same marked increases. Mothers who buy for Johnny aged four, suits sized for age 6 or 7, know this without benefit of science. Children are growing at an accelerated pace and reaching within the growth span a greater size. Since all parts of the body do not continue to grow at the same rate but follow a gradient, certain alterations in proportion follow upon this expansion in height.

So far as the evidence is available, this progress, if one may call it that, of the American type affects all our population regardless of origin. As long ago as 1912, Professor Franz Boas published his inquiry into the effects of the American environment on the bodily form of recent immigrants. He found that the children born in the United States of European immigrants were appreciably modified from the norms of their parents. My own investigation on the Japanese in Hawaii, although concerned with a different stock, led me, after controlled comparisons with the sedent population in Japan, to conclude that physical type is plastic under changes in environment and capable of significant alterations in size and proportion.

As a result of this increasing stature of the American people, both the new and older stocks, our average now surpasses those of the various European countries from which our population is derived. It should not, however, be assumed that the people of the United States alone are undergoing this expansion in height. In various parts of Europe, in Japan, and in other areas where statistics are available, the same process seems to be affecting mankind. Here in Amer-

ica it is apparently accelerated but not unique.

Even if this trend should appear desirable and we take pride in our rising statures, we should soon reach a point where further increases would become rather alarming. If stature has been increasing steadily for the past 75 or 100 years and our college men already have attained a mean of 5 feet 10 inches, where will it all end? Are we experiencing a transformation into giantism, with averages of 6 feet 6 inches or 7 feet within several hundred years or so? Are we headed for ungainly dinosaurian proportions that will lead to our extinction? Professor Mills, of Cincinnati, says no. His recent analysis of the latest data reveals a slowing down of the process, which presumably means a stabilization or possibly a reversal in the trend.

The precise cause of our increase in size is not completely understood. It has been attributed to a variety of factors, among others to improved nutrition, better care of our young, and advances in public health. But none of them seems entirely satisfactory since some of the tallest men in our army of 1917-18 came from areas that enjoyed none of the advantages in nutrition, medical care, and public health that we often think are typical of all parts of the United States. That nutrition, for example, does influence the growth cannot, on the other hand, be denied. Numerous studies on growth agree that children on better regimens do grow more rapidly and attain greater size than their less fortunate fellows. We are probably confronted here with a complex phenomenon which defies an explanation based on a single variable.

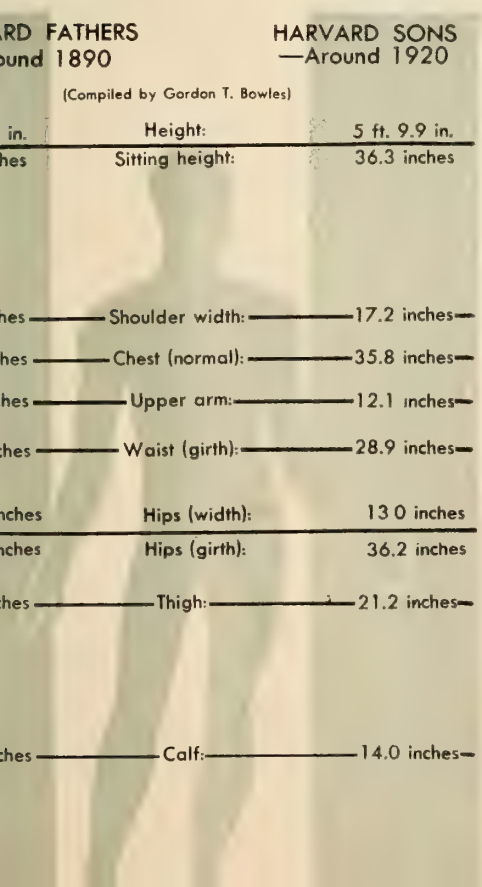
It may well have occurred to the reader by this time to wonder how far the American people are evolving a characteristic American type fundamentally distinct from those of our European contemporaries. Indeed, it was firmly believed at one time that Americans were gradually assuming the aspect of an Indian, on the hypothesis that the same environment that produced our predecessor was transforming us into his simulacrum. Peter Kalm, the Swedish botanist who visited the United States in the middle of the eighteenth century, professed to find "that the French, the English, Germans, Dutch, and other Europeans, who have lived for several years together in distant provinces, near and among Indians, grow so like them, in their behavior and thoughts, that they can only be distinguished by the difference of their colour." But even this surviving mark of distinction was thought by some to be disappearing. The president of Princeton College, Samuel Stanhope Smith, D.D., observed in 1788 that a change had already become manifest in the Anglo-Saxon and other European inhabitants of America, both in complexion and feature, and he further maintained that if the colonists were thrown like the Indian into a state of absolute "savageism" they would soon be marked by the same complexion.

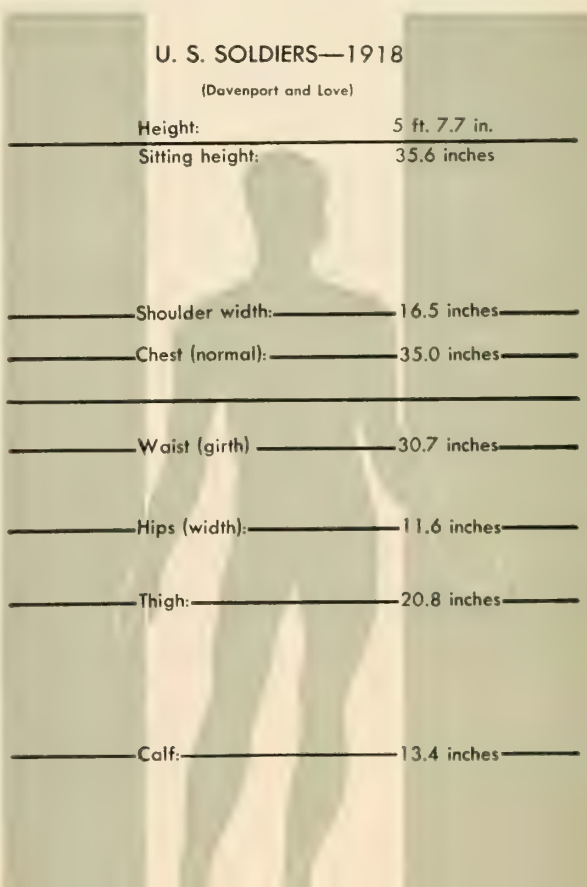
This belief seemed to enjoy a persistent adherence, because as late as the middle of the nineteenth century Dr. Carpenter, writing in an English cyclopedia remarked, "It has not been pointed out, so far as the writer is aware, by any ethnologist, that the conformation of the cranium seems to have undergone a certain amount of alteration, even in the Anglo-Saxon race of the United States which assimilates it, in some degree, to that of the aboriginal inhabitants. Certain it is, that among New Englanders more particularly, a cast of countenance prevails, which usually renders it easy for any one familiar with it, to point out an individual of that country in the midst of an assemblage of Englishmen. . . . And it is not a little significant, that the well marked change which has thus shown itself in the course of a very few generations, should tend to assimilate the Anglo-Saxon race to the aborigines of the country."

So do errors reverberate down the corridors of time. An echo of this strange doctrine came to my ear not very long ago via a well known professor of English literature who repeated this fantasy with complete conviction. If this were indeed true, then those who, referring to the United States, have urged that we "give it back to the Indians" might have been speaking with more poetic justice than they expected. But any such fanciful notion must be laid aside. The American of today remains a close derivative of the stocks that have settled here, but he has at the same time undergone modifications from his ancestral types. His deviations from European norms are either the results of mixture among the various representatives of Old World types or the consequence of an increased size with the attendant changes in bodily proportion that follow on such a quantitative expansion.

HARVARD SONS were ten pounds heavier than their fathers, 1.4 inches taller, and had shoulders 4/10 inch wider

THE SOLDIER of 1918 was shorter and lighter than the Harvard student but had a larger waist. Figures for the soldier of 1945 are not available





Birds of Paradise

By Ernst Mayr



THE AMERICAN MUSEUM OF NATURAL HISTORY

No. 127

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By

ERNST MAYR

MAN AND NATURE PUBLICATIONS

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THE AMERICAN MUSEUM OF NATURAL HISTORY

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A.M.N.H. photo

Deep in the jungle's forbidding wilderness, these magnificent creatures enact a drama of enchanting beauty. Centuries of search have revealed their secrets, and now the finest existing collection enables the American Museum to offer the public a spectacular new exhibit

Birds of

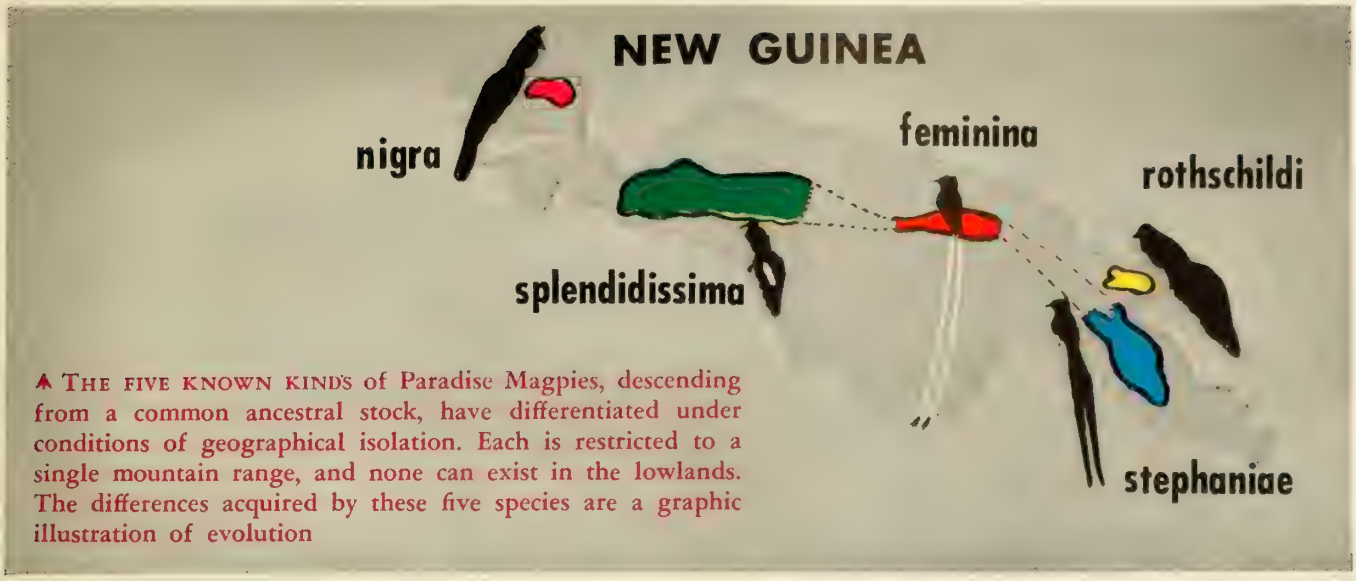
By ERNST MAYR

Curator of the Whitney-Rothschild Collections, American Museum of Natural History

▲ GREATER SICKLE-BILL (*Epimachus fastosus*). In its display the male resembles a long-tailed giant butterfly. Although restricted to the mountain forest above 5000 feet in western and central New Guinea, this bird was already known to the eighteenth century naturalists through skins collected by the natives

THE birds of paradise richly deserve the epithet "the most beautiful birds in the world." Theirs are not only exquisite colors, such as oranges, greens, blues, and reds of many shades, combined in harmonious patterns; what gives them their real distinction is their plumes. The many shapes into which Nature has been able to mold their feathers are a constant source of amazement. There are the true plumes of the genus *Paradisaea*, which surpass the feathers of egrets in soft daintiness. Others have the prismatic sparkle of highly polished metal, their reflections changing with the angle of the light to pass through the whole spectrum of the rainbow. The Superb Bird of Paradise has a velvet cape of softness and dignity to make every well-dressed lady envious. The most astonishing feathers of all are the plumes of the King of Saxony's Bird of Paradise. This bird is no larger than a small thrush, but it produces on either side of its head a thin "feather" a foot and a half long, whose simple wirelike shaft is bedecked on one side with two-score little horny plates like silvery-blue flags.

So extraordinary is the plumage of these birds, which are found nowhere outside the New Guinea area, that some were known to Oriental traders and seafarers centuries before the actual discovery of their native home. As a result, some fantastic ideas grew up about the birds. The first skins to reach Europe were brought by El Cano who, after the death of Magellan, took over the command of the first circumnavigation of the globe. At the small Moluccan Island of Tidore, the Rajah of Batjan presented him with several bird of paradise skins, which reached Spain on September 6, 1522. These skins had been prepared by New Guinea natives in the customary way by taking out the body, cutting off the legs, and drying the skin over a fire. The curious legless skins with the beautiful long plumes led to some amusing stories. Girolamo Cardano, for ex-



▲ THE FIVE KNOWN KINDS of Paradise Magpies, descending from a common ancestral stock, have differentiated under conditions of geographical isolation. Each is restricted to a single mountain range, and none can exist in the lowlands. The differences acquired by these five species are a graphic illustration of evolution

Paradise

ample, wrote in 1551: "The 'Birds of the Gods' come from the Moluccas where they are picked up dead on land or in the sea. They are never seen alive. Since they lack feet, they are obliged to fly continuously and live therefore in the highest sky far above the range of human vision . . . the back of the male is hollowed out and the female lays her eggs into this cavity and incubates them while the male continues flying . . . they require no other food or drink than dew from Heaven." The name Bird of Paradise was given them in the belief that Paradise was their true home.

At this time their plumes were already in use as customary ornaments by the Janizaries of the court of the Sultan of Turkey, as reported by Belon (1546-1549). The first (and very inadequate) illustration of a bird of paradise was published by the Swiss naturalist Gesner in 1555. All these early reports seem to refer to the Greater Bird of Paradise (*Paradisaea apoda*). In 1605, Charles L'Ecluse was already able to give a short but accurate description of three

▼ EMPEROR WILLIAM'S BIRD OF PARADISE (*Paradisaea guilielmi*). At the climax of its courtship display, the male hangs upside down

A.M.N.H. Kodachrome





TEN of the 20 genera of birds of paradise are known to cross and produce hybrids, as shown by this diagram. Two of these (in black) cross with species of only one other genus. Three of them (in blue) cross with two. Four of them (red) cross with three. The Superb Bird of Paradise (yellow) is known to produce hybrids with four other genera. (The colors are represented arbitrarily)



SWAMPY LOWLAND FORESTS, particularly with sago palms, are the favorite haunt of the Twelve-wired Bird of Paradise. When exposed to the sun, the delicate orange of the plumes bleaches to white. The female is plain: brown and black above, barred buff and brown below

A.M.N.H. photos



A NEW MUSEUM EXHIBIT OF "RIFLE BIRDS," as the black birds of paradise, with velvety and iridescent colors, are sometimes called. As if to make up for the simplicity of their black dress, these birds have developed some of the most bizarre ornamental plumes known among birds

BIRD OF PARADISE eggs are mostly orange streaked with brown. ose of six different species are reproduced here in actual size. At er left is the Twelve-wired Bird of Paradise. Right upper and ter are the Australian Rifle Bird and the Paradise Magpie respec- ly. The other three are Plume Birds. (Actual size.)

After Ernst Hartert, in Novitates Zoologicae

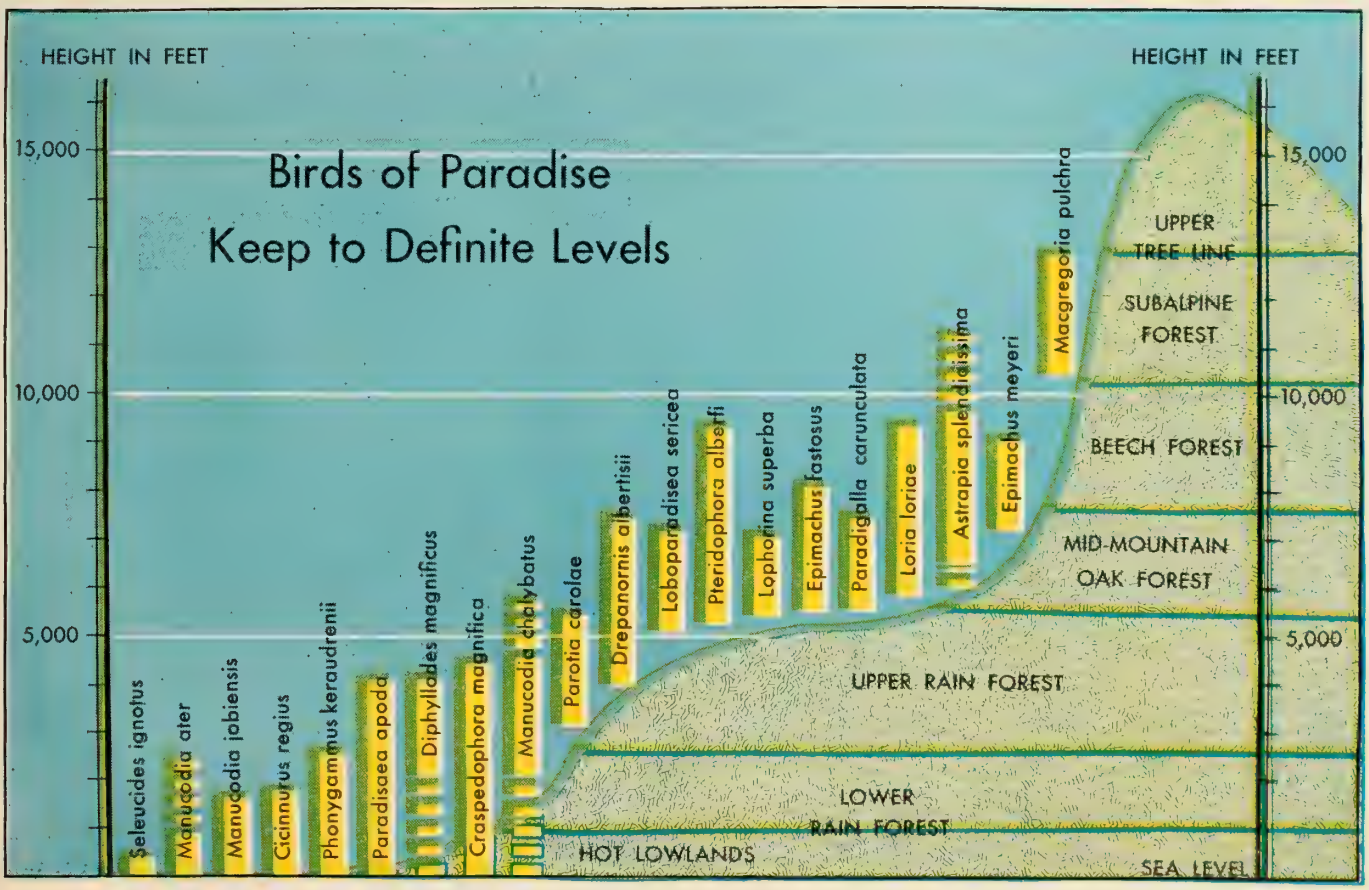




A.M.N.H. Kodachrome

▲ THE LESSER BIRD OF PARADISE (*Paradisaea minor*) was one of the most important "plumed birds" of the feather trade. Countless thousands were killed annually early in this century to adorn ladies' hats. Groups of males have "dancing parties" in a favorite tree where they display their plumage in an effort to win the favor of visiting females

BIRDS OF PARADISE are restricted to definite elevations like all animals. he chart below shows the ranges of 20 species in relation to the zones of egetation on the slope of the Snow Mountains in South New Guinea





A.M.N.H. Kodachrome

▲ THE BLUE BIRD OF PARADISE (*Paradisaea rudolphi*) is named in honor of the ill-fated Archduke Rudolph of Austria. It is found only in the mountains of southeast New Guinea. In its upside-down display it spreads its delicate blue plumes fanlike

species, but François Valentyn (1726) was the first to describe in detail the plumage, habits, and distribution of six species. Since then, the exploration for birds of paradise has made rapid progress. A new species was discovered in the interior of New Guinea as recently as 1938.

The thrill of the search for birds of paradise was conveyed by the celebrated naturalist Alfred Russel Wallace, writing from Aru almost one hundred years ago: "The first two or three days of our stay here were very wet, and I obtained but few insects or birds, but at length, when I was beginning to despair, my boy Baderoon returned one day with a specimen which repaid me for months of delay and expectation. It was a small bird, a little less than a thrush. The greater part of its plumage was of an intense cinnabar red with a gloss as of spun glass. On the head the feathers became short and velvety and shaded into rich orange. Beneath, from the breast downwards, was pure white, with the softness and gloss of silk, and across the breast a band of deep metallic green separated this color from the red of the throat. Above each eye was a round spot of the same metallic green; the bill was yellow, and the feet and legs were of a fine cobalt blue. . . . Springing from each side of the breast, and ordinarily lying concealed under the wing, were little tufts of grayish feathers about two inches long and each terminated by a broad band of intense emerald green. These plumes can be raised at the will of the bird and spread out into a pair of elegant fans when the wings are elevated. But this is not the only ornament. The middle feathers of the tail are in the form of slender wires about five inches long, which diverge in a beautiful double curve. About half an inch of the end of this wire is webbed on the outer side only and colored of a fine metallic green and, being curled spirally inward, form a pair of elegant glittering buttons, hanging five inches below the body and the same distance apart. These two ornaments, the breast fans and the spirally tipped tail wires, are altogether unique, not occurring on any other species of the 8000 different birds that are known to exist upon the earth. . . . My transports of admiration and delight quite amused my Aru hosts who saw nothing more in the "Burong rajah" than we do in the robin or the goldfinch.

"Thus one of my objects in coming to the Far East was accomplished. I had obtained a specimen of the King Bird of Paradise (*Paradisea* [*Cicinnurus*] *regia*), which has been described by Linnaeus from skins preserved in a mutilated state by the natives. . . . The emotions excited in the mind of a naturalist, who has long desired to see the actual thing which he has hitherto known only by description, drawings, or badly-preserved external covering—especially when that thing is of surpassing rarity and beauty—require the poetic faculty fully to express them. The remote island in which I found myself situated, in an almost unvisited sea, far from the tracks of merchant fleets and navies; the wild, luxurious tropical forest, which stretched far away on every side; the rude, uncultured savages that gathered round me—all had their influence in deter-

mining the emotions with which I gazed upon this "thing of beauty." I thought of the long ages of the past, during which the successive generations of this little creature had run their course—year by year being born and living and dying amid these dark and gloomy woods, with no intelligent eye to gaze upon their loveliness; to all appearance such a wanton waste of beauty. Such ideas excite a feeling of melancholy. It seems sad that on the one hand such exquisite creatures should live out their lives and exhibit their charms only in these wild, inhospitable regions, doomed for ages yet to come to hopeless barbarism; while on the other hand should civilized man ever reach these distant lands and bring moral, intellectual, and physical light into the recesses of these virgin forests, we may be sure that he will soon disturb the nicely-balanced relations of organic and inorganic nature as to cause the disappearance and finally the extinction of these very beings whose wonderful structure and beauty he alone is fitted to appreciate and enjoy. This consideration must surely tell us that all living things are *not* made for man. Many of them have no relation to him. The cycle of their existence has gone on independently of his and is disturbed or broken by every advance in man's intellectual development; and their happiness and enjoyments, their loves and hates, their struggles for existence, their vigorous life and early death, would seem to be immediately related to their own well-being and perpetuation alone, limited only by the equal well-being and perpetuation of the numberless other organisms with which each is more or less intimately connected."

The writer is often asked by would-be young explorers what chances there are for the discovery of new birds of paradise. Crystal gazing is not my profession, and the only answer I can give to such a question is based on an estimate of probabilities. Since 1910, only one good species of bird of paradise has been discovered, and even that is a geographical representative of three other mountain species that had long been known. I would judge, therefore, that the chances are exceedingly slight. However, it is a virtual certainty that unknown *races* will be discovered in the unexplored mountains in the interior of New Guinea. As late as 1929, I discovered a new race of the little Golden Silky Bird of Paradise (*Loboparadisea*) in the Herzog Mountains, near Lae of recent battle fame, a species previously known only from the Snow Mountains of Netherlands New Guinea.

The most striking discovery of recent years was the male of the Ribbon-tailed Paradise-Magpie in 1938, of which the inconspicuous-looking female had been known already for 25 years. This magnificent bird has two extremely long silky-white central tail feathers with black tips. The rest of the plumage is black and dark green, the glossy parts sparkling in all the colors of the spectrum. It is not surprising that this bird has escaped discovery so long, because its range lies in the most inaccessible part of central New Guinea, in the mountains between the headwaters of the Fly and Sepik Rivers. While most or all of the species are known, so little is known about their habits and life history that any student is sure to make his share of discoveries. There are at least ten species whose habits are still completely unknown.



A.M.N.H. photo

↑ THE SUPERB BIRD OF PARADISE (*Lophorina superba*) has two sets of plumes. One is a breast shield of a glossy green; the other is a cape of velvety black feathers which can be raised over the head. The inside of the mouth is brilliant yellow and is displayed prominently against the background of the raised black cape

Elusive birds of paradise

One reason why Lord Rothschild asked me, in 1927, to go to New Guinea was to search for the so-called "rare birds of paradise." This term has a special meaning. In the days when the plume trade was flourishing, tens of thousands of bird of paradise skins went every year through the hands of the great plume dealers in the Indies, Paris, Amsterdam, and London. These dealers, among whom the Dutchman Duivenbode and the French dealer Mantou were best known, discovered each year in their shipments from New Guinea a few skins that did not seem to belong to any known species. Lord Rothschild and other collectors were willing to pay fabulous prices for

these specimens, which they subsequently described as new species. In later years, it was discovered that some of these skins had come by devious channels from inaccessible mountains in remote parts of New Guinea. More than a dozen of these species, however, defied all the efforts of even the most resourceful hunters. Lord Rothschild did not give up hope, however, and when he sent me to New Guinea it was in the expectation that the home of these rare species would eventually be discovered. I was to make a thorough survey of a number of isolated mountain ranges in that region.

I had a most successful expedition in every way except with respect to Lord Rothschild's pet project. I did not rediscover a single one of the rare birds of paradise. My failure to do so, however, was indirectly responsible for the eventual solution of the puzzle. It set Professor Stresemann of the University of Berlin on the track of these birds, and by a careful study of the museum specimens he came to the conclusion that all the fifteen rare birds of paradise, whose homes could not be discovered, were actually hybrids of well-known species. This conclusion is now universally accepted.

Frequency of crossing

The question has often been asked why hybrids are so common among birds of paradise. But are they really common? If one or two such hybrids were culled out of an annual crop of 30,000 to 50,000 plumes, it would mean that only one out of 20,000 birds is a hybrid. This is certainly not a very high ratio. Even so, there is reason to believe that it is higher than among most other birds. The reason is obvious as soon as we recall the breeding habits of these birds. The nestling female bird never sees her father, and her younger brothers as well as her mother are of a simple coloration, totally unlike that of the adult male. The mature female is attracted to the display ground when she is ready for mating and leaves the male soon after. It is only to be expected that she will accept a mate of another species oftener than will females of species in which the members of a pair live together for days, weeks, or months before the actual start of reproduction.

The American Museum's collection of birds of paradise was very meager until about twenty years ago. Dr. Leonard C. Sanford, generous trustee of the Museum, who has done so much to build the Bird Department, was fully aware of this deficiency. In 1928, he sent Rollo H. Beck to northeast New Guinea and the writer to Dutch New Guinea to fill some of the gaps, and in 1929 they were followed by the Whitney South Sea Expedition, sponsored by Harry Payne Whitney, which concentrated on British Papua.

The result of these efforts was the finest collection of birds of paradise to be found in America but, alas, still a very poor second to the famous collection in the private museum of Lord Rothschild in England. This collection, resulting from 40 years of concentrated effort, contained nearly every known kind of bird of paradise, including about seventeen that were for the first time described by Lord Rothschild himself. Furthermore, this collection was of inestimable scientific value, because it contained large numbers of young, female and male birds in various stages of molt, giving a complete picture of variation and evolution in this wonderful group.

It seemed utterly beyond our fondest hope that the American Museum should ever come into possession of such a magnificent collection. It was therefore an overwhelming surprise when in 1932 Lord Rothschild offered his entire collection for sale and Mrs. Harry Payne Whitney seized the opportunity to donate it to the American Museum. It gives this institution by far the finest representation of birds of paradise existing in the world. It has since been augmented through the explorations of Richard Archbold and his associates.

Although primarily a research collection, the Museum has long felt that visitors would appreciate a public exhibit of birds of paradise, presenting the latest information on the remarkable displays of these birds. Through the interest and generosity of Colonel C. V. Whitney, it has been possible to carry out plans for such an exhibit, originally conceived by Dr. Sanford. Most of the illustrations on the accompanying pages are based on photographs of these new exhibits in Whitney Memorial Hall at the American Museum of Natural History.

Birds of paradise are believed to be resplendent relatives of the crow family. Indeed, the most primitive birds of paradise, the four species of manucodes, look very much like small crows, except that the plumage has a more pronounced purplish or bluish sheen. Males and females in this group are colored alike, although the males are slightly larger. Most persons would hardly believe that these plain birds are birds of paradise. Yet they are connected with the more bizarre types by an unbroken series of intermediate forms.

Recent students recognize 39 species and 59 subspecies of birds of paradise, grouped in twenty genera. The ornithologists of the nineteenth century had the habit of naming newly discovered birds of paradise for the crowned heads of Europe, to honor them and perhaps to please them sufficiently for a raise in the annual appropriation for their respective museums. This custom displeased the French ornithologist Charles Louis Bonaparte, nephew of Napoleon. When he finally had a chance to name a newly discovered bird, he called it "A Republican Bird of Paradise" with the following amusing explanation:

"Since I for my person have not the slightest regard for the sovereignty of all the princes in the world, I have adorned the most exquisite bird of paradise with the name of the Republic: that Republic which would be Paradise, if it had not been turned into Hell by evil tricks and through the ambition of so-called Republicans unworthy of the name they claimed for themselves. . . . However, even though a paradisean Republic does not exist, at least there is now a *Paradisea respublica* (a Republican Bird of Paradise)."

Unfortunately there are no good English names for about eleven of the groups in which the known 39 species may be divided. The brightly colored ones are sometimes referred to as "plume birds," and the black ones with metallic feathers as "rifle birds," but this classification of convenience oversimplifies matters. A diagram reproduced on page 274 shows the family tree of the birds of paradise and divides them into a few convenient groups.

No less bizarre than the plumes of the birds of paradise are their courtship habits. To be sure, there are a few species that live a very conventional and proper family life. It is more than a coincidence that these same species lack the extraordinary plumes and color. The manucodes

are black with a greenish blue or purple gloss. Both mates co-operate in the building of the nest and in raising the young. If these birds behave like their close relatives, the crows, it will be found that the female alone incubates the eggs. No observations on this point are yet available. The males, however, have one very extraordinary feature: their trachea, or windpipe, is more than twice the normal length and is coiled up in a big loop on top of the breast bone.

Recent observations by Dr. Rand indicate that in Macgregor's Bird of Paradise the male also participates in the raising of the young. In all other species, so far as we know, the female is alone and completely responsible for the cares of nest building, incubation, and feeding the young. The males devote their entire existence to feeding and courtship. No wonder they have enough surplus energy to develop their famous plumes as well as to engage in all sorts of odd performances.

It is by no means easy to observe birds of paradise in the wild. Their complicated display poses, therefore, have first been described chiefly from zoological garden specimens. Captivity does not seem to interfere with the normal course of their behavior. It seems that a bird in a cage will go through the same motions he would in nature. What the captive specimens do not tell, however, is whether the courtship is solitary or communal.

On the basis of my own observation, I would say that the display of most of these birds is solitary. Exceptions are the true plume birds (*Paradisaea*) and perhaps the flag birds (*Parotia*). Dr. Rand has added to this category Macgregor's Bird of Paradise, whose males engage in communal courtship chases.

Special "dance floors"

The flag birds, which are limited to the unbroken mountain forests, clear a piece of ground as their "dance floor." There must be a number of low horizontal twigs on which the birds strut. Coming on one of these clearings in the forest, I could always tell whether it belonged to a *Parotia* by the presence of these horizontal branches. There is another bird of paradise that lives in much the same surroundings and prepares little clearings on the forest floor. It is the Magnificent Bird of Paradise. However, most of its perches are vertical—numerous small saplings, at least partly stripped of their foliage. The male performs its curious display while climbing up





A.M.N.H. photos

▲ THE PARADISE MAGPIE (*Astrapia atra*) leads a solitary life in the mountain forest. It does not indulge in spectacular displays

◀ THE LONG-TAILED FLAGBIRD (*Parotia wahnesi*) is restricted to the Huon Peninsula. The Flagbirds are also sometimes called the Six-wired Birds of Paradise



▲ WALLACE'S STANDARD-WING (*Semioptera wallacei*) lives in the Northern Moluccas. Most of the plumage is pale brown, but the triangular breast shield is brilliant green. The ribbonlike plumes, or "standards," are raised in the display

▼ THE PLUMES of the King-of-Saxony's Bird of Paradise (*Pteridophora alberti*) are considered the most peculiar feathers to be found in the bird kingdom. This is a rare bird of the mountain forest in central New Guinea





▲ THE KING BIRD OF PARADISE (*Cicinnurus regius*) is also called Money-bird because of the coinlike tips on the long wirelike plumes. This is a common bird of the lowland forest

▼ THIS MALE of the Magnificent Bird of Paradise displays in an almost upsidedown posture to a female perched above him on the same sapling. Note the raised ruff and the wirelike plumes

A.M.N.H. photos



▼ THE RANGE of the bird of paradise family. Each group of dots indicates how many kinds of birds of paradise might be found in a cross-section as shown at the foot of page 265

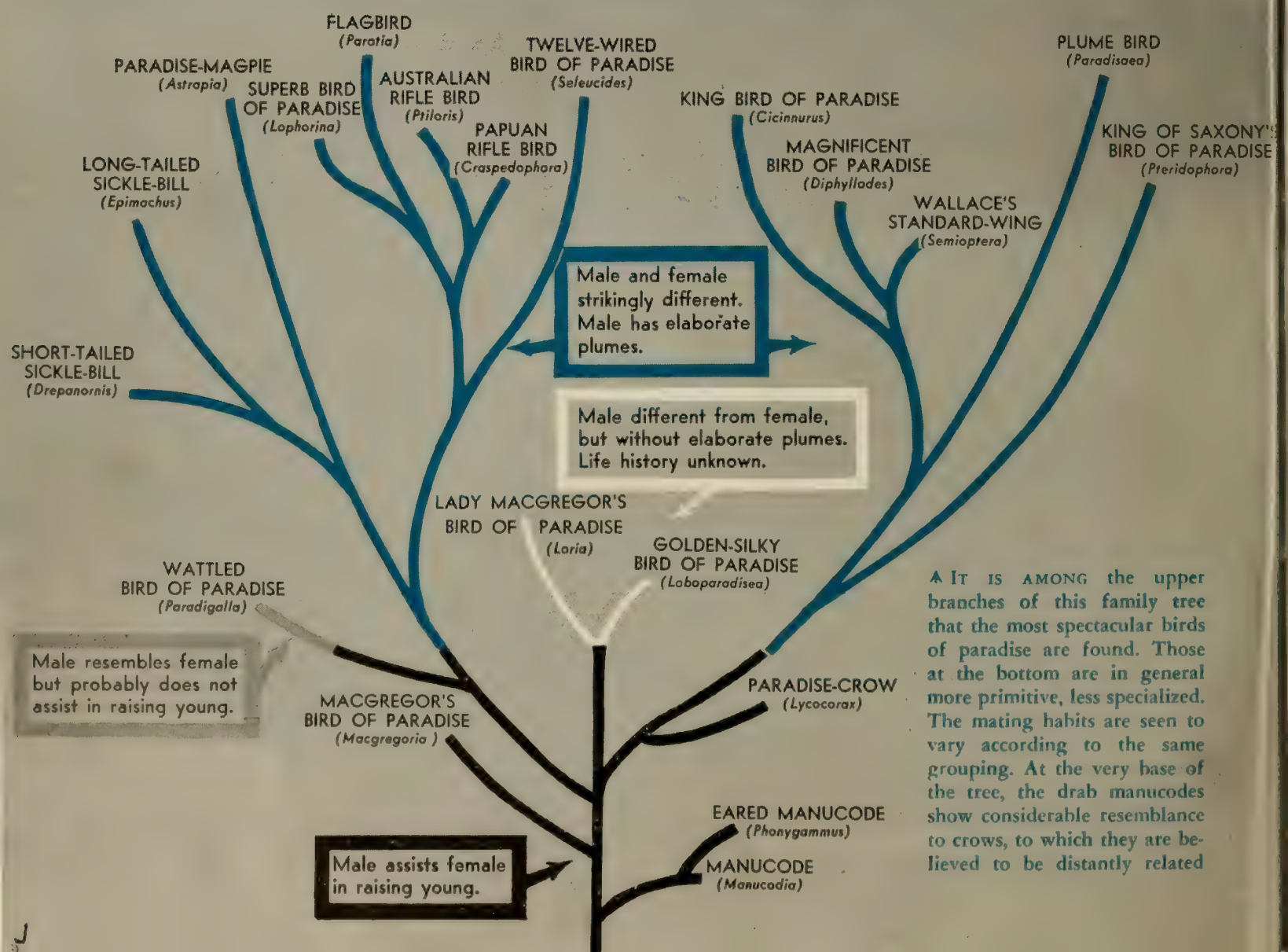


and down these vertical perches. A single male owns each of these display grounds and guards it jealously against any intruder of the same sex, as described by Dr. Rand in NATURAL HISTORY for March, 1940.

These seem to be the only birds of paradise that have regular display grounds. All the others may well have a favored tree or even a perch, but it looks like any other in the forest.

Their future

With heavy fighting going on in New Guinea and with hundreds of thousands of troops stationed along its shores, one may ask whether or not the existence of these birds is threatened. Some apprehension is not unjustified in view of the restricted ranges of the various species. Still, I feel that no danger exists at present and that the birds of paradise will continue to survive and even to flourish, provided no additional danger develops. Two factors, more than anything else, are likely to cause ex-



▲ IT IS AMONG the upper branches of this family tree that the most spectacular birds of paradise are found. Those at the bottom are in general more primitive, less specialized. The mating habits are seen to vary according to the same grouping. At the very base of the tree, the drab manucodes show considerable resemblance to crows, to which they are believed to be distantly related

tinction, as shown by the history of birds in New Zealand and Hawaii. One is the destruction of habitat, the other the introduction of alien species. These latter act either as predators, as competitors, or as carriers of diseases and parasites. In view of the vastness of New Guinea forests, the efforts of conservation should be directed principally against voluntary or accidental introduction of alien species.

That even heavy hunting in an undisturbed habitat does not necessarily lead to extinction is well illustrated by the history of the plume trade, which began, at least in a small way, fully 500 years ago. As more and more white people settled in the East Indies, the demand for plumes rose. Finally, enough of them were imported to Europe to attract the attention of fashion designers. The plumes were featured on ladies' hats, and fabulous prices were paid for them. Wallace describes how the natives of Aru hunted the birds around the middle of the last century: "They shoot the birds with a bow and arrow, the arrow having a conical wooden cap to the end as large as a tea cup, so as to kill the bird by the violence of the blow without making any wound or shedding any blood. The trees frequented are very lofty; it is therefore necessary to erect a small leafy covering or hut among the branches, to which the hunter mounts before daylight in the morning and remains the whole day, and whenever a bird alights they are almost sure of securing it."

Beginning about 1880, the hunting of birds of paradise developed into a prosperous trade and reached a peak about 1910. Malay and Arab plume hunters penetrated far into the unexplored regions of Dutch New Guinea and along the coast. Whole towns subsisted on the plume trade. Hollandia was a town of 700 in 1923. In addition to the Malay hunters and their Papuan companions, there were Chinese, Arab, and Dutch traders. The prohibition of hunting in 1924 brought about a slump, and when I visited the region in 1928, Hollandia was a regular ghost town of only 30 or 40 people, like some of the famous mining settlements in the West.



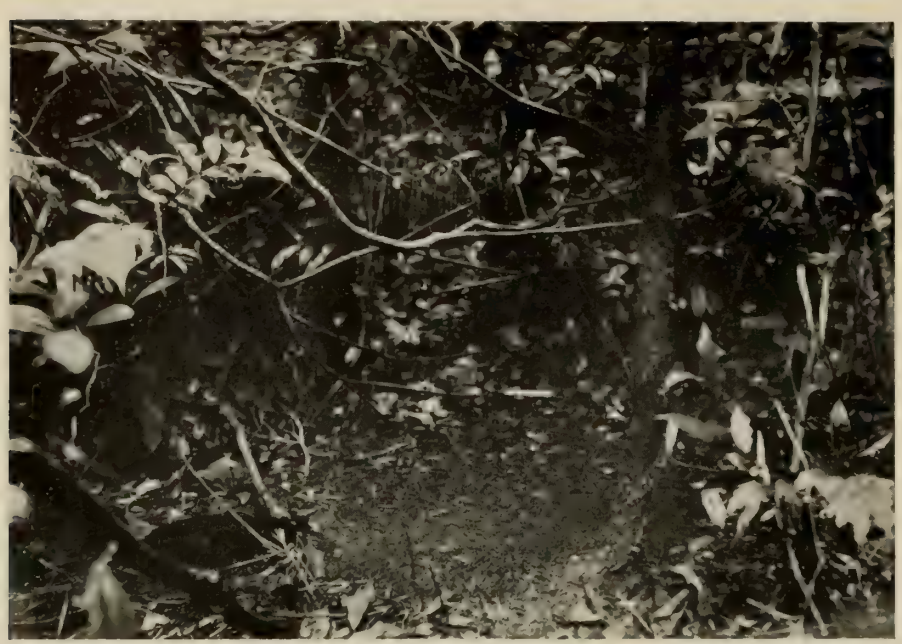
➤ **A PAIR of Magnificent Birds of Paradise in courtship. The male is in the full glory of his display, with his velvety shield glistening like burnished metal and his yellow cape thrown forward**

Drawing by B. F. Chapman

The hunting of the plume birds was a strictly seasonal affair. Though male birds of paradise do not have a regular eclipse plumage like certain ducks and passerine birds, they have to go through an annual molt like all birds. Naturally, the plumes are in best condition shortly after this molt. The Malays knew by experience when that date was reached and fixed on it the opening of the season. Hundreds of small expeditions then left the coast to settle in some village in the interior, which served as the base of operations. From here every morning, Papuan hunters went to the neighboring forest to hunt for males in full plumage.

After several months, when all the trade goods had been exhausted and all the adult males in the neighborhood collected, the little expedition made its way back to the coast. Here great celebrating took place, and I am told that between gambling and drinking many of the Malays lost all their hard-won gains within a period of a few weeks.

In former German New Guinea and in the Australian part of New Guinea, the hunting was usually in the hands of the white residents. The hard-struggling colonists found in this trade a means of support while waiting for their plantations to mature. Most of the plantations in eastern New Guinea grew coconuts, which do not begin to yield profits until they are about 8 or 10 years old. Meanwhile, the plantation labor had to be paid, and in the absence of any other income, the birds of paradise were a lifesaver to many of the colonists. In a few weeks they could collect enough birds to pay for all the expenses for the rest of the year.



Ernst Mayr photos

CERTAIN birds of paradise prepare "dancing grounds," in which the male displays his iridescent plumage in an elaborate courtship ceremony. (*Above*) Nicely spaced horizontal branches characterize the dance floor of the Flagbird. (*Below*) Vertical branches are required by the Magnificent Bird of Paradise on which to perform



The number of skins exported annually from New Guinea was appalling. In 1913, for example, no less than 30,000 birds of paradise appear to have been offered for sale in London auctions. In the years before the last war, around 10,000 birds were exported annually from German New Guinea alone. In a single shipment in 1912, a British firm received 28,300 skins. Some figures indicate that as many as 80,000 were exported from Dutch New Guinea in a single year.

Conservationists throughout the world feared that birds of paradise were definitely threatened, even though the hunters spared the females and immature males and did not hunt out of season. Finally, the season on birds of paradise was closed completely. Since 1924, no birds of paradise have been collected legally, and even the illegal hunting has been negligible. When I visited Hollandia in 1928, I was surprised to discover that birds of paradise were displaying right in the outskirts of the town. There were numerous display trees within a few miles. Obviously, the birds had made a wonderful recovery within only four years. The mountain species, of course, had never been under pressure. If they are scarce in collections, it is either because their habitat is very remote, as in the case of King Albert's Bird of Paradise, or because they are very rare even in nature.

So much for the birds in their natural home. Words can never fully portray their beauty. And for this reason, New York is fortunate in having this new exhibit, in which are displayed a number of outstanding specimens from the world's finest collection, along with related information. It is hoped that many persons will see it.

MASKS AND MEN



SCIENCE GUIDE

No. 128

THE AMERICAN MUSEUM OF NATURAL HISTORY

NEW YORK, N. Y.

People in all parts of the world wear masks: to imitate—to disguise—to protect.

To us, masks by themselves are curiosities or works of art. When worn in ritual or festival, however, they evoke vivid emotional responses, both in the wearer and in his audience.

We experience the magic of masking as children at Hallowe'en, and at Mardi Gras and masquerades; also when masks are worn by actors or outlaws.

That same experience has moved man since the days of the ancients.

The Iroquois give their wooden False Face masks life by carving them from growing trees. They represent bodiless demons who bring misery to man. If treated well, they are a protection against witches.

Braided corn husk masks once belonged to the Husk Face Society. The Huskers, a mutual aid club, represented thirty strange beings with corn husk faces. Today Huskers appear only in pairs as dancing officers at Council House ceremonies.



TWISTED FACE MASK

Ages ago the only being on this continent was one False Face, who refused to move when the Creator told him that other beings were coming to live there.

The Creator ordered him to look away while He marked a line on the ground to separate their lands. False Face turned away but kept peeking, until at last he turned around completely. The Creator caught him in the act and struck him such a blow that his face was knocked out of shape. And so it has remained to this day.

From an old Iroquois legend

In a smoke-blackened lodge, Athapascan Indians hold the Festival of the Masks. This is a series of thanksgiving dances for fish and game, and a plea for further abundance.

Wearing masks of the thinking spirits of animals and singing songs which honor them, the dancers give thanks to these spirits.

Some of the dances, like the imitations of The Grouse, The Old Woman, and The Old Man, are pure entertainment.



GROUSE MASK

The movement of a drumming grouse is imitated by a kneeling masked dancer. He is assisted by two women and by a clown in a grotesque mask, who mocks the drummer's actions.

OLD MAN MASK



In a masked skit, Old Man is disturbed by a bad dream of a man in a grotesque mask. The dreamer tries to drive him away but he returns many times before the dreamer finally succeeds in driving him off.

Eskimo masked dances, like the Athapascan dances, are held to give thanks and win over the thinking spirits of all creatures.

By wearing the mask of a spirit, the dancer assumes its power. During certain religious festivals women dance with small, round masks on their fingers.



As the Eskimo dances the movable parts of his mask sway in time with his body. This is considered an important part of the dance. Music is provided by a solo singer and a background chorus. The rhythm is beaten out on a parchment drum or tambourine.

The spectators, mostly women, add their voices to the chorus. The songs tell either of mythical or real events, based on legends or real hunting or fishing experiences.

The world of the spirits comes to life when these Indians dance at night in huge, shadowy houses barely lit by yellow fire-light. By startling dramatic tricks and sleight-of-hand, masked dancers bring the audience face to face with their spirit ancestors.

These masks are used by medicine men and by clans and secret societies founded and protected by animal spirits. In winter, the secret society dances are the occasion for social life, religious ceremonies, fun and excitement for the people. The dancers enact the founding of the society by animal ancestors who could change to human form and back again. By pulling hidden strings to open and close the double and triple masks, the dancer shows this important change. To the audience, the actors seem to be spirits performing supernatural feats.

CANNIBAL SPIRIT MASK



This is the Cannibal Spirit Mask of the Kwakiutl Indians. The body of the Cannibal Spirit is covered with mouths and his servants catch men and gather corpses for him to eat. In his house live the Cannibal Bear and also the Cannibal Raven who eats the eyes of the men whom his master has eaten. Human beings to whom the Cannibal Spirit appears develop a craving for human flesh.

Among the Pueblo and village Indians of the arid Southwest, ceremonies center about fertility and harvest, rain and growth. The failure or success of crops depends upon the powerful Gods of the Sun, the Earth, the Wind and the Clouds. Kachinas, spirits of the dead, act as go-betweens for these Gods and man. The Kachinas are represented by costumed, painted, and masked men who lose themselves in the personality of the Kachina mask.

The Zuni mask maker sprays his mask with seeds which he has chewed, saying: "Now I have given you life. I have made you with seeds and given you life. Bless us with your strong spirits and whenever our day may come, call the rains for us as long as you live. I have made you into a person."

The Indians of the Southwest attach great symbolic importance to color. Yellow is the color of the moon and the symbol of rain. This Hopi yellow half-mask is worn by female Gods. The Hopi gives the mask life by painting it. So sacred is the paint that when the old color is scraped off it is placed in a Kachina shrine.

HALF-MASK



After the Spanish Conquest, missionaries introduced new carnivals and processions in place of the old Indian dances. Many masks and costly costumes were used to show the Passion of Christ, the Conquest and the battles between the Moors and the Christians.
Today these carnivals are still held. They are social as well as religious and a main amusement of the people.



MATACHINE MASK

Matachine dancers perform at church fiestas and other ceremonies. Eight to twelve men dance to the music of violins and guitars. Faintly resembling the Virginia Reel, the dance is directed by one or two leaders who indicate the figures with a fan held in the left hand.

The dance of the Spanish Conquest is one of the most popular dances in Guatemala.



CONQUEST MASK

Like those of Mexico, the carnivals of Guatemala take as their theme the Spanish Conquest. This mask portrays a European in the Conquest story.

Dance masks are found almost everywhere in South America. In many places they are made only for a special occasion and then destroyed.
In prehistoric times it was the custom to put masks over the faces of the dead.



MUMMY MASK

In Peru from about 1000 to 1400 A.D. the coast people buried their dead in mummy bundles to which false heads were attached. On this false head there was a face, either painted or in the form of a mask made of wood or metal. This mummy mask is made of wood with shell eyes.

In Africa masks have many magical and religious uses. They are worn in the rites of secret societies, in ceremonies initiating boys and girls to adult life, in war dances, and by medicine men in making magic and in curing the sick.

The white masks of the Ibo of Nigeria represent re-embodied spirits who return to earth with white faces. White-masked men called maws run around with whips and sometimes throw down yams as offerings.
The maw usually speaks with a whistling tone, produced by holding in his mouth a small piece of wood with spider webs at each end.

MAW MASK





INITIATION MASK

When Bampende boys enter into manhood they wear an initiation costume and mask during the entire ceremony. During this time they hide in the forest or the bush, keeping out of sight of other people. Women would surely die if they looked upon the masks.

As part of Buddhist ritual, Tibetan temple dances are held to welcome the New Year and to drive out the bad luck demons of the old year. These are the Mystery Plays in which Buddhist monks or lamas wearing awesome masks portray gods and demons. Acting the vivid pageant in the temple courtyard, they show the power of lama and church over demon and human enemies.



HVA-SHANG MASK

Hva-shang, a Chinese monk, came to Tibet in the eighth century. The lamas made him ridiculous in their religious debates. Hva-shang is the "stooge" of the Mystery Play. He is pushed about and forced to worship Tibetan gods, and the audience is delighted when a tray of barley is thrown in his face. Defeated, he staggers from the courtyard.

Actors in Japanese NO and KYOGEN plays are masked. NO is the established drama based on folk tales of Japan and nearby countries. The stage sets, the magnificent costumes, the characters and even their facial expressions are set by tradition. The expressions of the masks correspond to the personality of the characters in the play.

The KYOGEN comedies are shown between the scenes or as part of the NO play.



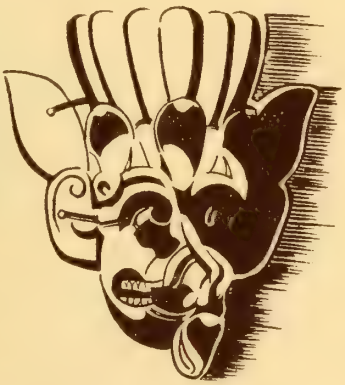
UZUME MASK

The Sun Goddess once became angry at her brother the Storm God, and retired to a cave in a rage. The anxious people, deprived of the sun, gathered and begged that she come out, but she refused. At last the jolly goddess Uzume came to the cave and did a dance so droll and shocking that all the heaven dwellers burst into laughter and the Sun Goddess forgot her anger and returned to her people.

In Ceylon, masks are worn in the traditional plays and in dances to cure the sick. The theatrical masks represent stylized character types.

The Sinhalese think disease is caused by devils, and a devil dancer wearing a demon mask is called to make a cure. During the ceremony the drums and music grow wilder and wilder and the dance more frenzied. The dancer faints when the demon leaves the sick man to enter his body. The dancer is then carried out as dead and the patient is cured.

GURULA MASK



The sacred eagle Gurula who frees mankind from poisonous snakes is the hero of a popular scene in the dance drama. He appears when the beautiful Serpent Virgin enters the King's court to sing with the people. Gurula flies through the air and, although other snakes come to help the Serpent Virgin, he devours them all and drinks their blood. The mask of Gurula shows him devouring snakes and wrapped in coils of fighting cobras with spread hoods.

The Javanese drama takes its themes from two great mythical cycles of India, the Ramayana and the Mahabharata. Actors at the courts of princes and travelling players have fascinated generations of audiences by the same stories, characters, costumes, music and gestures. The type of mask indicates the kind of character portrayed, God or demon, elegant or coarse, good or evil.



HANUMAN MASK

Hanuman, the General of the monkey army, is the hero of a Javanese play. He helps a royal prince to rescue his kidnapped wife from the clutches of the demon king.

Masked dancers in Borneo act as peace envoys; catch and return the wandering souls of sick people; and insure good harvests by capturing the timid soul of the rice plant at planting time.



RICE
PLANTING
MASK

The Borneo native thinks that rice has a soul and if the soul is not present the harvest will be poor. To get the rice soul back to the fields, figures masked as powerful demons with long wooden hooks dance in a circle before the houses. In the dance they make sweeping movements of the hooks to entice the rice soul, which is timid and easily frightened.

The dancers who perform the ceremony are not allowed to speak. If they spoke they would fall dead since the real demons whom they represent are speechless.

Masks play an important part in the spectacular ceremonies of New Guinea and nearby islands. Between ceremonies the mask lies, sometimes forgotten, sometimes carefully guarded from the uninitiated. It then emerges, repainted and decorated for a new ceremony, to astonish the women and children and renew the men's sense of their own social and religious self-importance.



YAM MASK

Among the plains people of northwest New Guinea, the finest long yams are carried horizontally on poles at harvest time. These yams are treated as supernatural beings, and wear masks, and feather and leaf streamers as decorations.

The American Museum is grateful to the following:

MR. GREGORY BATESON
for scientific advice

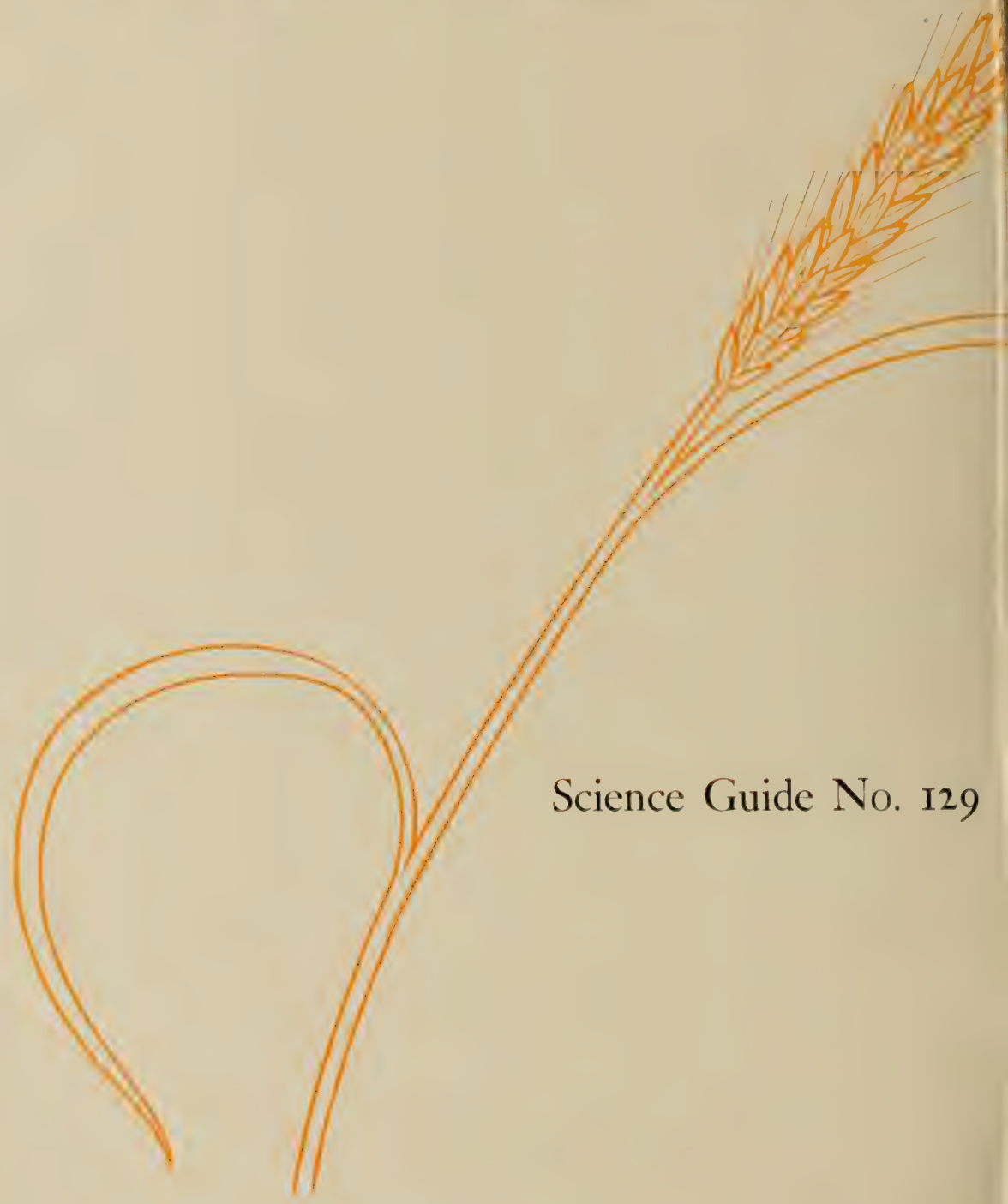
KATZENBACH AND WARREN, INC.
for sculptured wall covering

M. SCHWARTZ AND SON
for feathers

THE CEREALS AND CIVILIZATION



THE CEREALS



Science Guide No. 129

AND
CIVILIZATION

By Clark Wissler

Curator Emeritus, Department of Anthropology

The American Museum of Natural History

ENTRAL PARK WEST AT 79TH STREET, NEW YORK, N. Y.


McCORMICK-DEERING

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Introduction

THE three great staple food grains used by mankind are wheat, rice and corn (maize). They are of primary importance, so we speak of them as "the big three." The leading secondary grains are barley, rye, oats and millet. A serious world wide crop failure in any one of the "big three" would be a calamity.

All the seven grains we have designated are the seeds of grasses, originally wild. Nature seems to have so ordered the plant coverage of the earth that the grasses were destined to furnish the main foods for man and his herds. The grasses are basic because their stems and seeds sustain the animals upon which man depends for a large part of his daily diet.

In contemporary speech the word *cereals* is used to designate grains when eaten by man—derived from Greco-Roman mythology, the name of the Goddesses Ceres, traditionally responsible for the reproduction and growth of grain crops. However, the recent tendency is to use the word cereals to specify certain breakfast foods, such as cracked wheat, puffed rice, corn flakes, etc., in contrast to breads of various makes.

Civilization first came of age with the cultivation of wheat. Before the dawn of civilization was a long period of twilight during which hunting and gathering wild game, seeds and roots was the way of life. We know this from the study of surviving savages and from archaeology, which teaches us that Australia, for example, never had an ancient civilization, but was a land of savages down to 200 years ago. Science gives us faith to believe that man lived upon the earth more than 400,000 years before it ever occurred to him to sow the wild grass seeds he had long depended upon for survival and that civilization came to maturity less than 10,000 years ago.

Perhaps there is reason in all this, even 400,000 years may have been needed to give man time to overrun the whole earth, to sample all the numerous kinds of grass seeds and grass eating animals as the first necessary step in choosing the few best suited to provide food for his growing family. Further, it was so ordered by nature, that man could learn by absorbing the knowledge and experience of numerous generations and countless individuals that in the end large populations could be maintained and directed as teams to achieve still larger ends. It may well be that 400,000 years of conditioning was none too long.



THE SPREAD OF WHEAT CULTIVATION is indicated by the following approximate dates: valley of the Nile 5000 B. C.; Euphrates and Indus, 4000 B. C.; China, 2500 B. C., and England 2000 B. C. Further, the use of the cart, plow, and bronze spread over about the same area between 3500 and 400 B. C. Since these are important traits in ancient civilization, we can say that the area for wheat is also the area of ancient civilization. Note again that China and England are marginal and that the elements of civilization reached them last, diffused from the ancient centers of Egypt, Sumer, and India

After Carl Whiting Bishop, Annual Report of the Smithsonian Institution, 1940



EARLIEST CENTERS OF CIVILIZATION as defined by the ruined cities of On, Ur, and Mohenjo-Daro, the best known early sites. Further explorations may lead to new discoveries and some changes in the picture

Wheat

WHEN man developed the idea of sowing a grass seed and protecting the growing plant until gathering or harvesting time, it naturally followed that he would save some of the seed for the next planting time. The natural thing to do would be to select the best seeds for each planting and in this way the yield would be increased, but botanists remind us that there are other considerations. Wild plants are adapted to survive independent of man, hence they possess structural patterns which loosen the mature seeds so that they will shatter out of their hulls, easily fall to the ground, or are anchored to parachute-like devices which enables the wind to carry them abroad. A familiar example of the latter is the dandelion. Yet since man expects to harvest the seeds he sows, he must needs change the nature of the plants, that the seeds cling to their hulls and the hulls to the stalks, until man shakes them vigorously or beats them out. This is carried to such an end that many domestic seed plants are unable to reproduce unless man saves some seed and plants it at the right time of the year. There may be many other factors involved here but it is clear that neither wheat, barley nor corn are capable of surviving independently in a wild state, but are even more dependent upon man than are many of the domestic animals.

Although obviously derived from wild plants it is extremely difficult to identify the wild ancestors of wheat, barley, etc. When man began to farm he attempted to destroy the wild grasses to make room for his favorite crops. Further, he carried his seeds abroad, planting them where their wild ancestors were unknown. This coupled with the changes the selection of seeds has brought about in the cultivated forms, increases the difficulty of identifying the original plant. Plants, especially the grasses, seem prone to mix or cross with wild species, thus further complicating the problem. So we need not be surprised that the ancestors of wheat are still somewhat uncertain.

Again it is equally difficult to find the place and the time when the first plant was domesticated. What we certainly know is that most of the cereals were planted before writing was sufficiently advanced to record events, or more than 6000 years ago. Further we can be relatively certain that the first civilizations to come of age were among the wheat eaters. (Map. p. 5.)

ARCHAEOLOGY tells us that civilization first emerged on the edges of three widely separated mud flats at the mouths of as many rivers, or around the deltas of the Nile, the Euphrates, and the Indus. Each of these rivers runs the main part of its course through an arid terrain, the world's greatest stretch of desert lands. Westward from the Nile lie 2,500 miles of the Sahara; eastward, between

the Nile and the Red Sea is a long narrow desert; between the Red Sea and the Euphrates lies the great Arabian desert; between the Euphrates and the Indus lie the semiarid and desert lands of Iran and Baluchistan; immediately east of the Indus is the Indian desert. Though little rain ever falls on the lower courses of these three rivers, their upper branches traverse areas where heavy rains are periodical, causing annual floods in the deltas.

One would least expect to find the dawn of civilization in such a setting, yet on the edges of these deltas we find the ruins of predynastic Egypt, of Sumer, and of ancient India. Here emerged the first planned cities the world ever knew, such as On (Heliopolis), Ur, and Mohenjo-Daro, all flourishing about 4000 B. C.

Until recently Egypt was believed the oldest and so the mother of civilization, but archaeological research in Sumer around the year 1926 revealed cities of a more advanced type than in the Egypt of 4000 B. C. Then a few years later cities on the Indus were uncovered which threaten to contest the lead of Sumer. Expert opinion, however, tends to concede a slight lead in priority to Sumer. Yet archaeology goes further in giving satisfactory proof that Sumer and her successors along the Euphrates passed on to Europe much of the "glory that was Greece" and so can justly claim to be the "mother of Euro-American civilization."

There is little reason to suspect that these three centers of civilization developed independently, since they are not only contemporaneous but when looked at closely their respective ways of living follow a common fundamental pattern. The most conspicuous common element in this pattern is the use of wheat. Between the mere sowing of wheat grains and the consumption of bread derived from it is a complex of skills and processes, the details of which would fill a large book. However, we now present a brief and simple handbook recounting some of the most important incidents in the story of the food grains and the evolution of civilization.

The general pattern of this civilization may be characterized by cereals, domestic animals, the plow, the wheel, metals, writing, calendars, and cities. It is difficult to realize that these were then unique, novel traits of culture, appearing in the world for the first time. And what is more they are still the fundamentals of civilization.

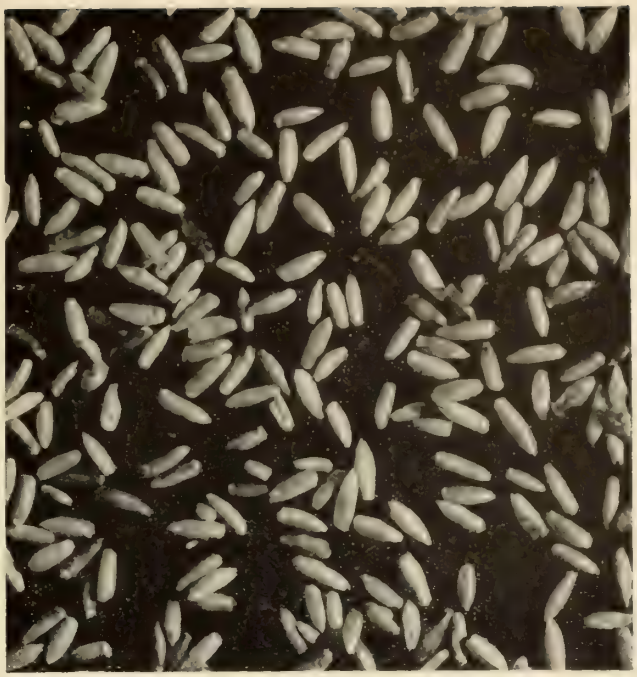
Again archaeology tells us that man had existed for several hundred thousand years before civilization happened. In the meantime he had overrun the entire world, but his numbers were limited by the amounts of wild foods available and his ability to seize them.

In contrast civilization arose some ten thousand years ago and was scarcely under way before 4000 B. C. What amazing changes has mankind experienced during these last 6000 years! But even more astonishing is it that between 7000 and 4000 B. C. were made all the basic inventions underlying our civilization. Nothing so revolutionary happened before or since.

The change in the way of living which set off this burst of inventive genius was the discovery of agriculture and the domestication of animals. We speak of this as revolutionary because it was a radical step. Throughout the long stretch of Old Stone Age time man simply gathered his food when and where nature made it available. For ages man was blind to his opportunities. Instead of pursuing and killing game animals, thus making them scarce and wild, he could have lived in friendly co-operation with them, protecting and conserving them, and living in luxury on their increase by the simple device of saving females and sacrificing the males. His native intelligence would soon reveal to him the principle of improvement by selective breeding. Within a generation or two he could have come into control of his animal food supply, instead of being dependent upon what nature offered him. All this seems so obvious to us that we are moved to lament the stupidity of man during 400,000 years



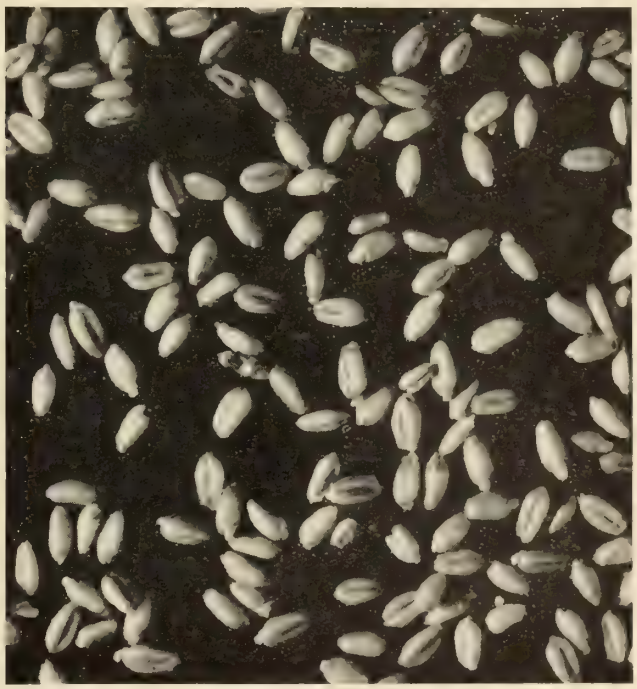
WHEAT



RYE



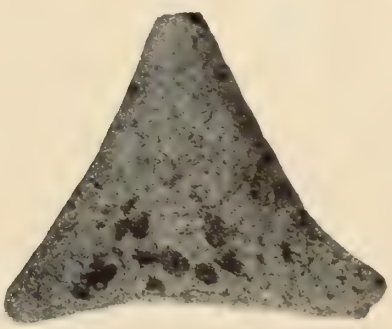
OATS



BARLEY

EARLIEST KNOWN BREAD

At the ancient Egyptian site of Deir el Bahri the elements of civilization appear associated with wheat and barley. Strange as it may seem, some loaves of bread survived owing to the dry climate. A magnifying glass shows barley to have furnished at least part of the flour. Age estimated at 3500 to 4000 years



Courtesy of The Metropolitan Museum of Art



A STRAIGHT SICKLE made of flint blades set in bone. Length, 20 inches. From Neolithic Period, Fayum, Egypt. (Adapted from *Antiquity*)

of the Old Stone Age.

Yet the less obvious was to discover what could be done with the seeds of wild grasses. We now know that the most concentrated form in which nature supplies food is in seeds, but again it took man about 400,000 years to realize the significance of seeds—to see that in the application of his particular brand of intelligence to the exploitation of seeds lay the key to his future. We may never know just when and where some primitive genius first achieved insight as to how seeds could be multiplied and improved, but we do know that with the raising of wheat in the region of the three great river deltas the first civilizations emerged.

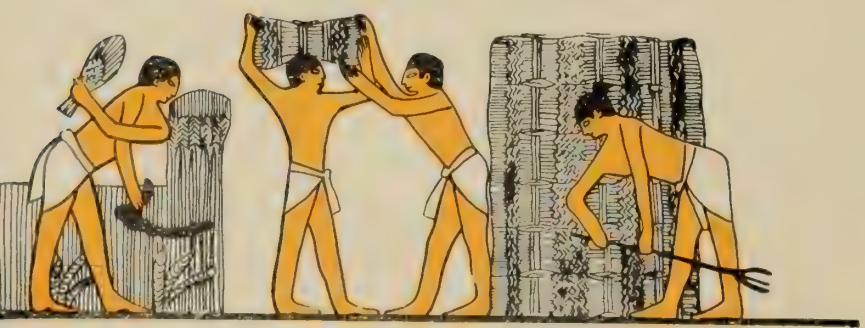
We gave the cereals first place in the fundamental characteristics of civilization because that is the verdict of history. The data from archaeology reveal that wheat, barley, and millet are the cereals which appear first. Later emerge rye, oats, and rice, all originally wild grasses. From the earliest known graves in the delta of Egypt come seeds of wheat and barley. In the delta of the Euphrates millet seems slightly earlier than wheat and barley; in the Indus valley, wheat appears with barley.

Everywhere wheat was preferred as it is still. It is abundant in yield, can be readily stored, preserved for a long time, and easily transported. Wild wheat (emmer) and barley survive in a few localities, ranging from Mount Hermon in Palestine eastward into central Iran both found growing together as man probably noticed them before he began to cultivate them.

NOW that we have taken note of the evidence that mankind after a long period of preparation rather suddenly domesticated plants and animals; that among these the cereals and a few food animals furnished the main foundation stones for our civilization; that wheat must be recognized as the cereal No. 1; we can turn to the important details of wheat culture.

Wheat Farming

Under the most conceivably primitive conditions wheat was sown broadcast to cover the ground thickly enough to discourage weeds and other grasses from intruding. No cultivation was attempted, but grazing animals must have been kept away and stray weeds and grasses pulled out by hand. Apparently man learned by accident that the best way to clear the ground for wheat was to burn over the surface before planting, thus not only destroying the old plant cover but killing the seeds of all the wild plants. Next the surface of the soil was broken up and after the grains of wheat were broadcast by hand, brush was dragged over the surface to cover up the grains, lest birds eat the most of them. In ancient Egypt, and no doubt in the low lands of the Euphrates and the Indus as



HARVEST TIME in Ancient Egypt. A laborer cuts the grain with a sickle. Others heap the bound grain before the threshing floor. (Adapted from *Mummies* by Richard A. Martin, Chicago Natural History Museum Publication)



A BONE HANDLE of a sickle from which the blades have been lost. Length, 15 inches. From Palestine. (Adapted from *Antiquity*)



A LATER TYPE of flint sickle with a curved cutting edge. From Egypt. (Adapted from *Antiquity*)



A BRONZE SICKLE of about 600 B.C. From Denmark. (Adapted from *Antiquity*)

well, wheat was sown on land flooded by seasonal rains at the headwaters of the respective rivers, before the new layer of mud spread by the water was dry; then sheep and even cattle were driven over the field, back and forth, to trample the seed into the ground.

When the grains of wheat were mature, or the straw turned yellow, it was time for the harvest. Men and women began at one side of the field to cut the stalks with knives, tying the straw into bundles with the heads always at the same end. No doubt a simple knife was the first to be used. The oldest knives especially devised for this purpose, were of stone; first a straight piece of wood or bone into which small flakes of stone were fastened, giving a saw-like edge. In ancient Egypt this soon evolved into a hooked stick and finally into the familiar curved tool we know as the sickle. In the bronze age sickles were made of bronze and later of steel. We still use a similar tool for cutting grass and weeds. The author remembers that steel sickles were still used in his community for harvesting wheat beaten down by heavy rains. Strange to say these sickles had cutting edges grooved on one side like files, thus giving a saw-like edge, possibly reminiscent of the ancient sickles with rows of tiny flint flakes.

After the harvest the bundles of wheat stalks were carried to a threshing floor, at first merely a smooth patch of ground, tamped down hard, upon which the grains of wheat were trampled under foot or beaten with sticks. Even in very ancient times cattle were often driven back and forth over the grain to trample out the seeds of wheat.

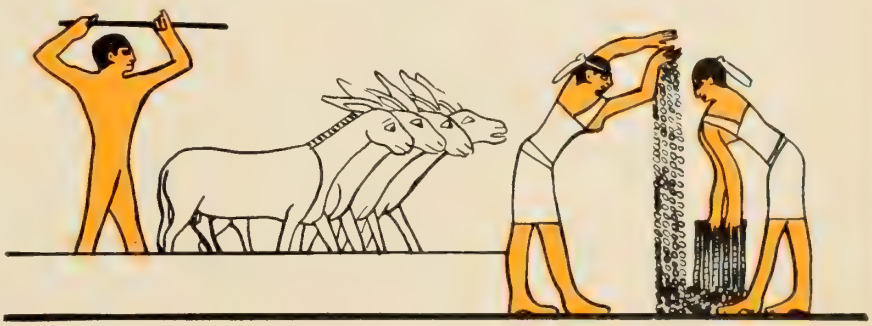


A MODERN steel sickle, with a wooden handle

The straw was then removed with a forked stick or a crude rake, leaving the seeds mixed with hulls or chaff. Removing the chaff is called winnowing, because the procedure was to toss a mass of chaff and grain into the air; even a light breeze is sufficient to deflect the lighter chaff aside from where the grain falls. The clean grain was then gathered up in baskets or bags for carrying to storage places.



MODEL of the Stenild sickle, found at Stenild in Jutland, and dating from the Bronze Age. Here a single flint blade is set at right angles to the handle. (Adapted from *Antiquity*)



HARVEST TIME in Ancient Egypt. Donkeys tread out the kernels on the threshing floor. Two women work at winnowing the grain. Drawings from a carving in an Egyptian tomb. About 2400 B.C. (Adapted from *Mummies* by Richard A. Martin, Chicago Natural History Museum Publication)

The Plow

For several thousand years there was little change in these methods, nor has the order of these processes ever changed, but within the past two hundred years many mechanical inventions and shifts from animal to steam and tractor power can be noted. One of the oldest inventions was the plow, still of primary importance.

The old theory was that the plow developed from the hoe, but now that we have more data on the early forms of the plow, it is clear that it evolved from the digging stick, a stick pushed into the ground to break up the soil. Possibly the first plow was drawn by men as shown in an Egyptian wall picture, but in other Egyptian drawings oxen and even donkeys are yoked to the plow. In one of the Egyptian drawings the grain seems to be thrown so that the plow will cover it, but a sketch on a seal from Babylon goes a step further in showing a seeding machine, the seed being dropped into a funnel which discharges it behind the point of the plow. This is a near parallel to a modern type of machine for sowing wheat.

These ancient plows seem crude and simple, yet the type survived until recent times. Around 1550 the Spanish introduced the plow and oxen into Mexico and thence to the Indians. As late as 1900 Pima and Papago Indians were using crude wooden plows in Arizona and northern Mexico, examples of which are in the collections of the American Museum of Natural History. Some of these were provided with stone points, indicating that the stone age still lingered here. The plow of today, the modern mould-board plow, was invented by Thomas Jefferson, about 1800.

PERUVIANS PLANTING POTATOES

THE ABORIGINAL FOOT-PLOW was an improved digging stick used to turn sod and hard ground. Simple forms of the foot or digging-stick plow were used in western Europe within the last century



Courtesy of the Chicago Natural History Museum

After James Henry Breasted, The History of Egypt

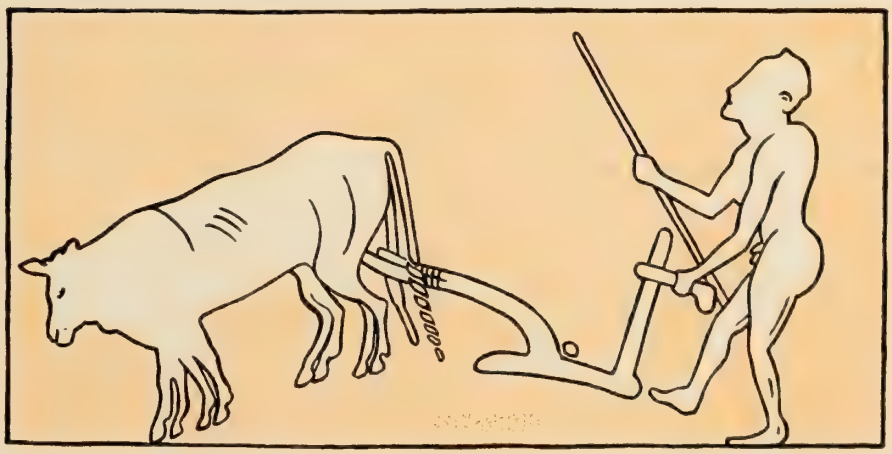


Egyptian plow drawn by cows. Note the two handles. It has been proposed that the Egyptian hoe, as shown at right, was the original form of the plow. But the simple digging stick and its successor the foot-plow are now considered the probable parental forms



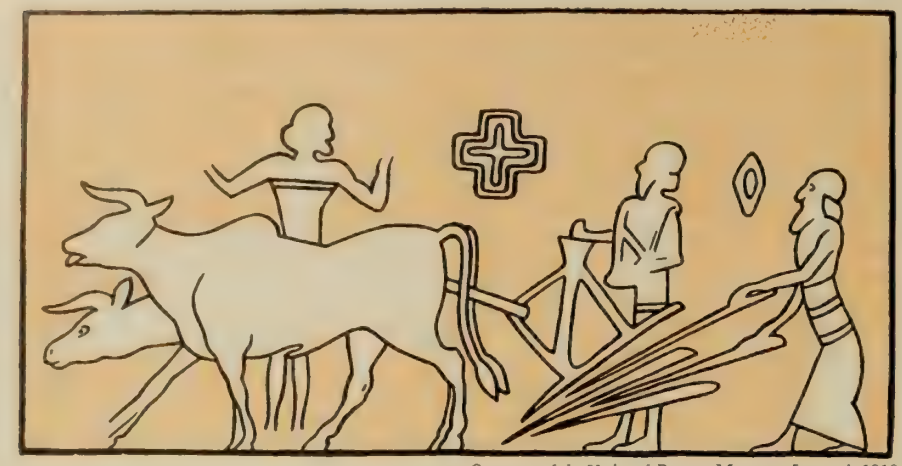
An Egyptian man-drawn plow. Grain is sown by casting into the furrow. 18th Dynasty, about 1400 B. C.

After Carl Whiting Bishop, Ann. Rept. Smithsonian Institution, 1937



Early Greek plow, from a vase painting. All these ancient plows used cattle, not horses. The horse appears relatively late in ancient civilization and was at first valued for its speed and use in war

After Carl Whiting Bishop, Ann. Rept. Smithsonian Institution, 1937



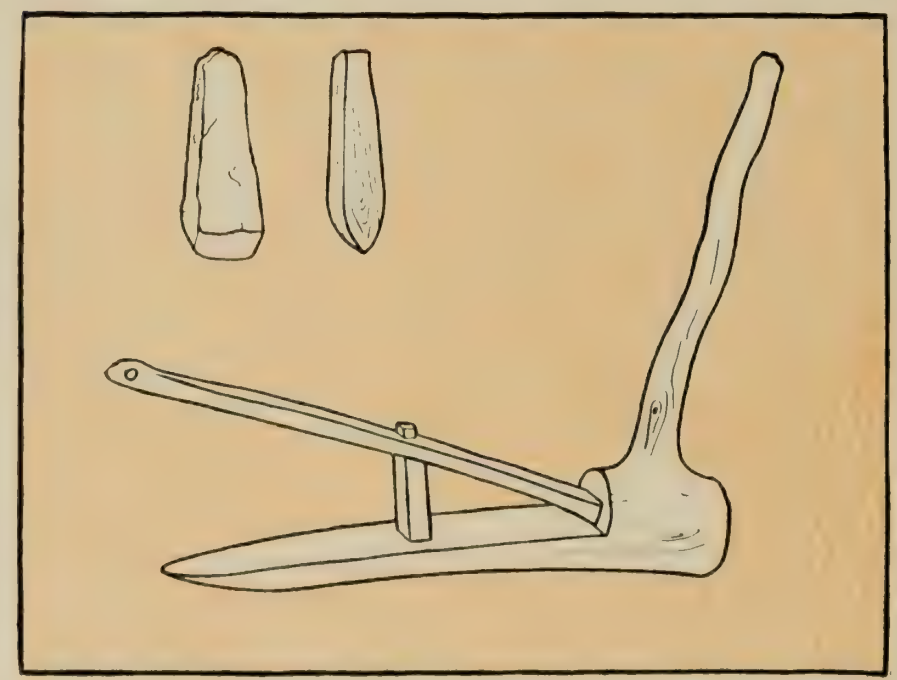
EARLIEST KNOWN MECHANICAL SEEDER. An ancient seal from the Euphrates country shows this plow equipped with a hopper to receive and sow the seed

Courtesy of the Univ. of Penna. Museum Journal, 1910

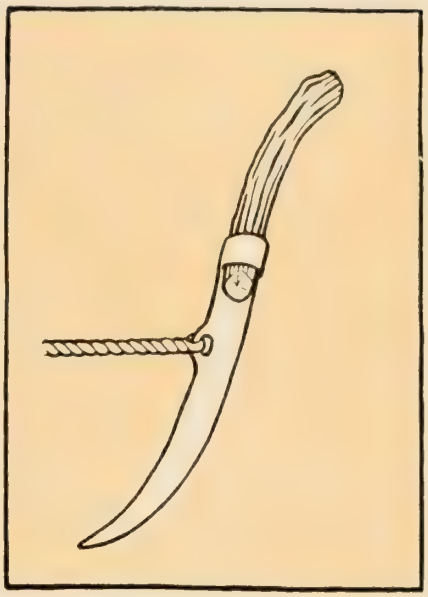
Harvesting Machines

Harvesting machines are for the most part less than a century old. As stated the oldest device was the sickle. In the British Colonies in America the first radical invention was the "cradle," a scythe with a frame-work attached to pay out the stalks evenly behind the mower, whence they could be easily gathered into bundles for tieing. Much later in the United States a reaper was devised, a machine drawn by horses or oxen, which cut a wide lane through the standing grain, dropping it in orderly fashion upon the ground. Later improvements bunched the wheat, dropping these bunches off ready to tie and still later devices gathered the wheat into an orderly bundle, tied it with twine and threw it upon the ground. Finally, an Australian is credited with combining a threshing device with a reaper which delivered the grain free from chaff as it was drawn along, now known as a "combine."

In the meantime threshing devices had passed through an independent evolution, the oldest invention was the flail, a simple two part club for beating the wheat by hand. Yet until the last century the universal method was to tread out the grain with horses or oxen. Then a machine with a toothed cylinder was invented, driven by a horse power tread-mill, quickly elaborated by adding a winnowing attachment using a rotary fan. Later a portable steam engine was used to supply the power, at first pulled about by horses or oxen, but later geared to draw itself



A SURVIVAL of the primitive plow is found among the Indians in Arizona and Mexico. As late as 1850, some of these plows were used with detachable wooden or even stone points



JAPANESE ceremonial plow in the form of a digging stick with an iron blade, drawn by man-power. From a drawing by the author; specimen in the museum of Tokyo

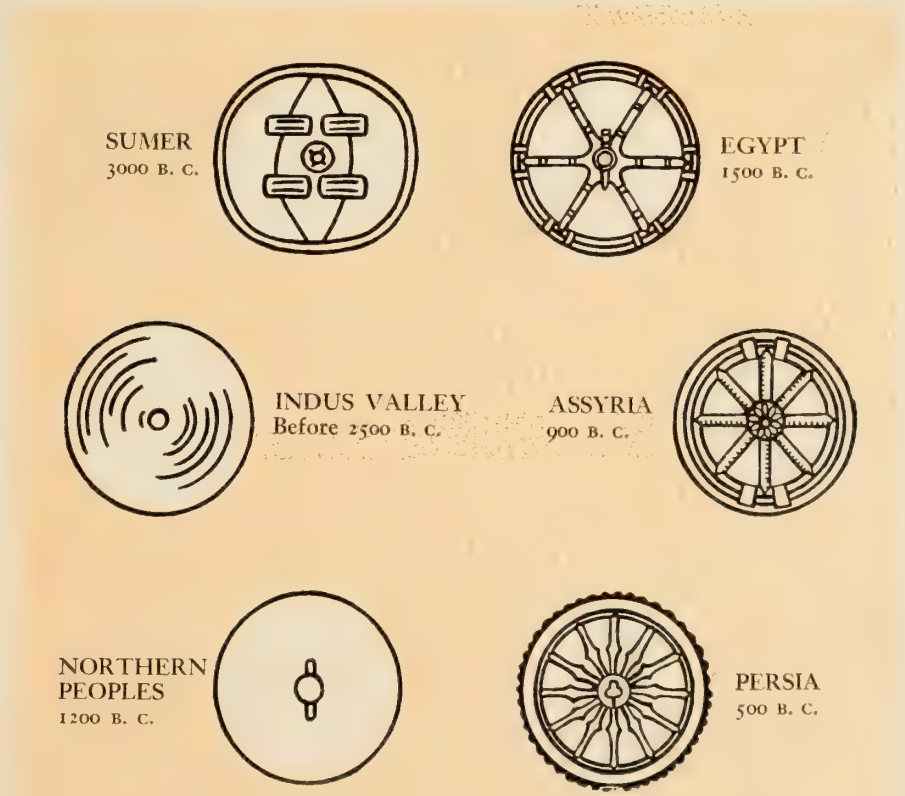
and the threshing machine by its own steam power. This preceded the automobile, finally to be replaced by the tractor.

The winnowing process was mechanized first by a "fanning mill," operated by a crank which facilitated the winnowing, universally used in days when animals trod out the grain. Historians tell us that the "fanning mill" was invented by the Chinese several centuries before it appeared in Europe. Since pictures in ancient Chinese books are duplicates of European models, the whole device was no doubt copied from these people. The threshing machine and the combine merely incorporated the "fanning mill" into those devices.

Flour

Practically all the wheat eaten by man is in the form of bread made with flour. In primitive times wheat was treated like wild seeds, crushed between stones or in a mortar. Yet since the ancient Old World civilizations understood the wheel, they soon devised the rotating mill or *querm.* At first this device was turned by hand as shown in the illustration, a device still used in many parts of the Old World. Eventually this device was mechanized, by applying water-power, wind-power, horse-power, steam, gasoline and electricity. Even in power mills, stone

After James Henry Breasted, Ancient Times



THE PLACE AND TIME for the origin of the wheel are obscure. Its distribution over the ancient world closely followed the ox and the donkey

discs were universal until about a century ago, when metal rollers were introduced, now almost universal, though here and there, even in the United States, water power mills with grinding stones are still in operation.

For a long time flour making was a household operation, the coarse parts of the wheat being sifted out of the flour by hand. Now a flour mill is a complicated factory, in which bran, shorts, middlings, etc. are separated from the residual white flour, and used for stock food.

The Wheel and the Cart

Since the wheel and the cart have played such a large role in the evolution of Old World civilizations, some note of them seems in place. Historians usually regard the wheel and the plow as among the few traits best characterizing the pattern of Old World civilizations.

If you wish to evaluate the wheel as a trait of civilization, try to imagine what would be left if the principle of rotation were completely blotted out. Power-driven transportation would disappear. Away would go windmills, water wheels, steam and electric power. All goods must then be carried on the backs of men and animals, in rowboats or in small sailing vessels. Even hand- and foot-driven machinery would be eliminated. We cannot conceive of a worthwhile world entirely ignorant of the wheel. The earliest known wheeled vehicles appear in Sumer, four wheelers drawn by donkeys. A little later we meet with the chariot, or cart, first drawn by donkeys, then by horses. Ox-drawn carts, also, are shown in ancient drawings and sculpture.

Domestic Animals

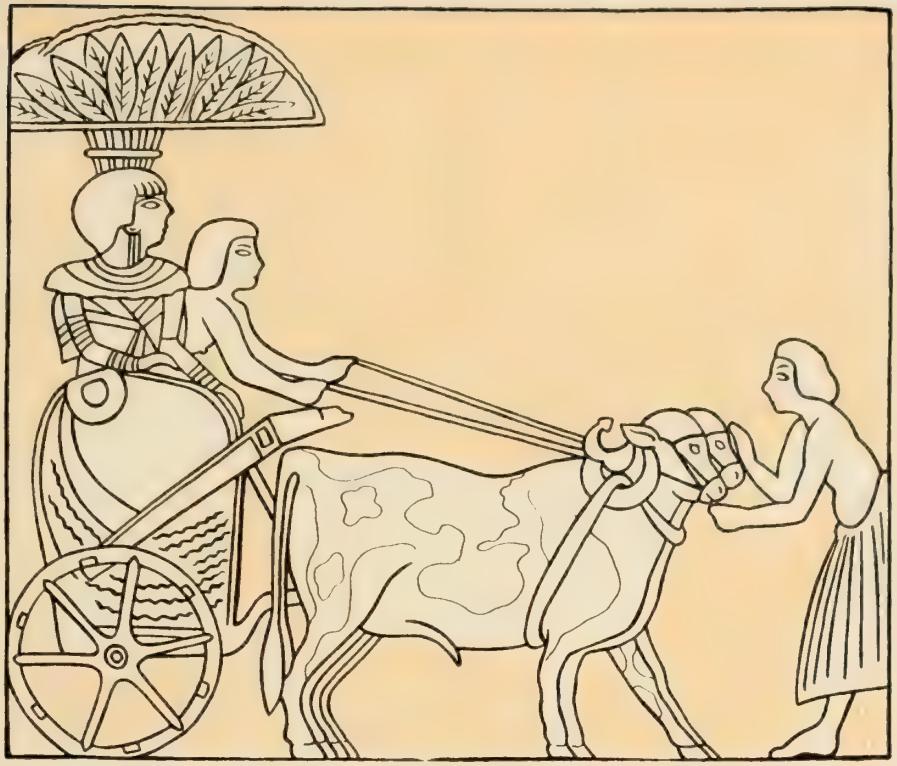
In equal measure the evolution of animal husbandry is pertinent. Not only are the ancient cereals still of vital importance, but the leading food animals—cattle, sheep, goats, and swine—are still the best. Their bones appear in the remains of these first civilizations, and there is abundant evidence of their early domestication in surviving sculptures and frescoes on the walls of temples and tombs. Aside from the ox, the first draft animal to appear is the donkey; the horse appears some 1,000 years later, and the camel still later.

We find early sculptures and wall paintings showing the milking of cows in stables. Many such pictures found in Egypt appear modern in that the hind legs of the cow are tied to prevent her kicking the milker, and the calf is kept in front of the cow to check any tendency to "hold up her milk," a trick still used by our farmers. There are lifelike scenes of cattle being driven and led from pasture to stable. In one instance a man walks in front of the cow with her new-born calf on his shoulders, a sure way to induce her to follow.

The wild ancestors of cattle, sheep, goats, swine, and the donkey seem to have lived in and immediately around the three great centers in which these ancient civilizations emerged. Hunting scenes in which wild bulls, boars, and donkeys are pursued furnish evidence that the wild species were not immediately exterminated by domestication. We suppose it was an accident of nature that the wild ancestors of the best domesticated seed grains, food and draft animals evolved in the same part of the world.

The History of Bread

However, the most significant part of the story of wheat remains to be told. Somewhere within the area shown in our map (p. 5) some baker of wheat bread discovered yeast and raised bread. Either writing was unknown or in its infancy at the time or the discovery may have seemed too trivial to record. Many modern writers suspect the discovery was made in Egypt. The Jews seemed to have learned the art from abroad since they found it necessary to bar the use of yeast bread in traditional religious rites.



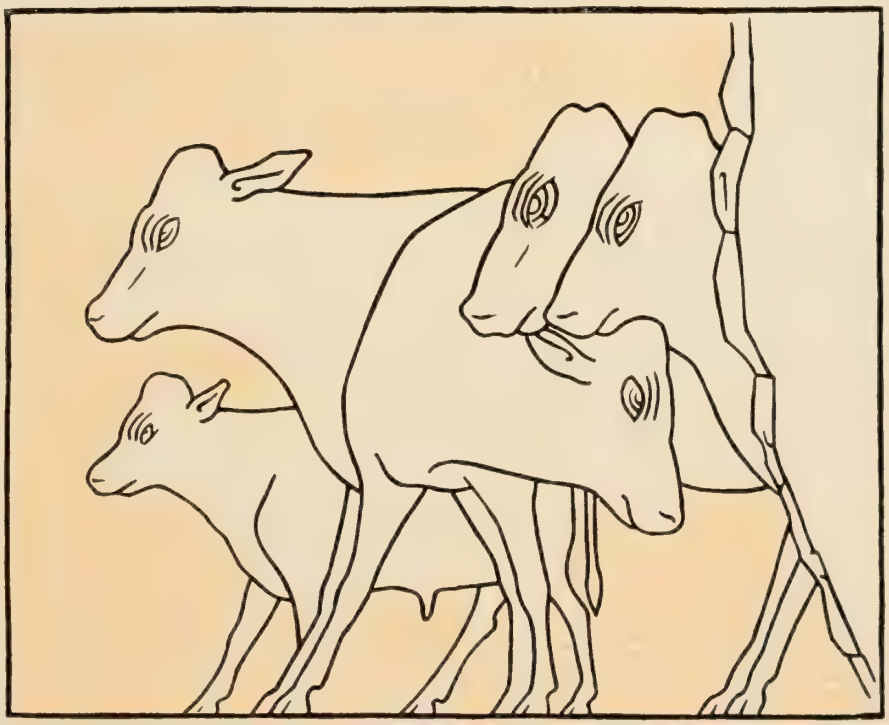
THE OX was sometimes used with a chariot in Egypt, as shown by this wall picture. The passenger is appropriately a woman. The men drove horses

Courtesy of The Metropolitan Museum of Art



THE EARLIEST portrayed war chariot had four wheels and was drawn by donkeys. Sumer, about 3000 B. C.

Courtesy of The Library of Science and Culture



SKULLS exist proving Egyptians bred both hornless and long-horned cattle, suggesting a long period of skillful breeding. 29th century B. C.

After James Henry Breasted, The Scientific Monthly

Naturally such new-style baking would profane all sacred rites and so be sacriligious. The mixing of yeast dough with fresh wheat flour starts a ferment which causes the dough to rise and become porous, or "light." When baked the heat kills the yeast and so stops fermentation, giving a light soft spongy bread. Wheat flour happens to be the only cereal producing successful "light" bread because it contains the proper amount of gluten to hold the gas bubbles resulting from fermentation. Rye seems to approach the standard but needs the addition of some wheat flour to make passable bread. So from that time to this man has preferred wheat bread thereby rating wheat the leading grain food.

There is an interesting book, "Six Thousand Years of Bread" from which we quote the following:

"Long ago Occidental man acquired a definite preference for raised bread instead of cooked cereals and flat breads. Bread reigned over the ancient world; no food before or after exerted such mastery over men. The Egyptians who invented it, based their entire administrative system upon it; the Jews made bread the starting point of their religious and social laws. The Greeks created profound and solemn legends for their Bread Church of Eleusis, and the Romans converted bread into a political factor. They ruled by it, conquered the entire world by it, and lost the world again through it. At last the day came when Jesus Christ made consumate all the spiritual significance that had become attached to it, saying:

"Eat! I am the bread." *

It is a long road from the indiscriminate gathering of wild grass seeds to yeast bread, but it was a glory road. Nothing seems to dwarf its greatness. Though what we know of its historic background is vague, it is logical. The reality is obvious and undeniable. The long and persistent survival of yeast bread is sufficient proof of its usefulness. Rice is still preferred boiled. Maize gives corn meal and corn bread, good food only when wheat bread is not available. Some imaginative people assert that it is the possession of true bread and, of course, wheat, which accounts for European culture dominating the world, but this is probably a case of "the cart before the horse." However, the superiority of wheat bread may well account for the cultivation of wheat wherever possible.

The most ancient civilizations of the Old World seem to have evolved among the wheat growers. Closely trailing them were the rice growers and next the maize growers of the Western World. There is reason to suspect that for a long time the evolution of each of the three great cereal areas (Map p. 17) was independent. The first to come in contact were wheat and rice civilizations; much later wheat using peoples found their way to the Americas, whence corn (maize) came to their knowledge, about 1500 A. D.

Archaeological data shows that the use of wheat is older than the use of rye. Rye, however, will grow in climates and soils unfavorable to wheat, but makes inferior bread. In time the superior bread making quality of wheat led to the evolution of wheats which would grow in colder climates, thus widely extending the wheat area and restricting the use of rye.

Rice

The second great cereal area centers in southeastern Asia and the adjacent island world, the motherland of rice eating civilizations. In contrast to wheat, rice originated in a tropical, rainy, marshy country. The cultivation of each spread abroad rapidly about as far as its growing habits permitted.

The area devoted to the cultivation of rice is evidence of its importance to man. The number of people who depend upon it for food is even more impressive. Almost every-

* Six thousand Years of Bread. H. E. Jacob. p. 17.

where in Southeast Asia, rice ranks as the main food. Because of the density of population in that part of the world, it is estimated that one half of the human race lives upon rice. The other half of the world's people occupy a much greater area, but for the most part they are bread eaters (wheat, barley, rye, and corn).

When we think of rice, we think of China, but in India rice plays an even larger role. British India alone, with a population of about 300 million, produces annually about 600 million bushels of rice. We have no good statistics for China with its 400 million people, but it is estimated that she produces less rice than India. Hence, it would be a mistake to rate China as a whole as being fully dependent upon rice, though rice is the chief food in the southern provinces.

In a region like the Philippines, native life is largely organized around the production of rice. Its importance is shown by the special rituals that accompany almost every phase of its cultivation and processing. It is the only food recognized by such ceremonies in the Philippines. As A. L. Kroeber expresses it in his well-known book,* "The native point of view is clearly that if the success of the rice is assured by the necessary magical and ceremonial means, other crops will automatically take care of themselves. When plant food is offered to the spirits in any connection, it is almost invariably rice. In short, the Filipino not only eats rice, but thinks in terms of rice, and if his civilization is to be described in a

* *The Peoples of the Philippines*, page 86. (Handbook 8, The American Museum of Natural History.)



The Three Great Cereal Areas of the World in 1500 A. D.

single phrase it can only be termed a rice culture."

We have noted that there is still some difficulty in identifying the wild ancestors of wheat and corn, but cultivated rice seems definitely to have come from a single species, *Oryza sativa*, native to the East Indies. All rices grown are regarded as varieties of this species, and they are surprisingly numerous. According to some writers, about a thousand varieties of cultivated rice are known in India alone, all of which are special strains, adapted to local differences in soil, temperature, and rainfall. In the main, however, a tropical or at least a subtropical climate is required. The plants are annuals and reach a height of two to five feet, with panicles (seed heads) roughly resembling oats.

The original wild species required low ground that was flooded at least part of the year. The cultivated varieties known as "hill," "upland," or "dryland" rice can be nursed through the growing season without flooding, but the yield is less and the grains smaller than in the aquatic varieties.

Rice Farming

One of the regions often chosen to best exemplify aquatic rice-growing is the Malabar coast of southwest India. This coast receives torrential rains in May, June, and July, followed by a period of moderately heavy rains in October. The dry season is from December to March. The lowlands of the coastal belt vary from 30 to 50 miles wide and are thickly populated by rice-growers. There are 1000 to 2000 inhabitants to the square mile. Originally these lowlands were covered with dense deciduous forests, which were later cleared for rice growing. All the land that can be flooded by impounding rainfall and river water is devoted to rice. Sixty to 120 days are required for a crop, depending upon local conditions. Harvest time is usually in September.

Before the rains begin, a simple pointed plow is used to scratch up the surface of the ground. Water buffaloes are preferred to oxen and are yoked to the plow either singly or in pairs. Cattle dung is spread over the

CULTIVATED RICE in the field *Photo from U.S. Dept. of Agriculture*





CULTIVATION OF RICE apparently came later in history than wheat. But wild rice was probably eaten in the East Indies long before the plant was domesticated. The only implements the first rice-growers used seem to have been digging sticks and wooden spades. Only after the cultivation of rice spread to the Asiatic mainland and contact was made with people who grew wheat and millet were the plow and draft animals adopted. "Dryland" rice, as distinct from that grown in flooded fields, was probably developed through watching wheat farmers at work



Photo by Lionel Green, from Frederic Lewis

plowed surface, which after the first rains is plowed once more, and the earth is finally smoothed by dragging a log back and forth.

When all is ready, the banks, or dikes, surrounding the field (paddy) are repaired. If the timing has been correct, the rains now begin, and as soon as the ground softens up, the rice seed is sown broadcast, sometimes trampled into the mud, sometimes not. The plants begin to grow in the water-covered soil. At intervals during the growing season, men and women wade into the rice paddy to pull out the intruding weeds. Finally, the water is drained from the paddy to permit the ground to harden. When the rice is mature, the heads are cut from the stalks with various kinds of knives or sickles. Immediately thereafter, millet, pulse, or sesame is sown. Water buffaloes, a few cattle, and sheep and goats are herded upon the wastelands and are fed in part upon rice straw, chaff, and other crop foods, such as millet, oil cake, etc.

Turning from the Malabar coast-dwellers to Asiatic and insular rice-growers in general, we find that wherever the growing period is short, rice may be sprouted and grown for a time in flooded beds and then transplanted by hand to flooded rice fields. This naturally adds to the labor of rice production.

When the rice grains begin to mature, the fields are raided by seed-eating birds, often in such numbers as to leave but a small harvest. A common method of keeping the birds away is to stretch a number of strings across each paddy, with streamers or pennants attached to them. These flap about when the cord to which they are fastened is jerked vigorously. Small platforms or towers are erected so as to enable a single watcher to guard four plots. This is no small task, because the flock, when disturbed, merely takes wing to descend at another location.

Processing the Crop

Threshing rice involves two operations. As in oats, a hull or husk firmly encloses each grain, and this must be removed by rubbing or gently beating the grain in a mortar or upon a mat. The most primitive way is to tread barefoot upon the unhulled grain.

The next step is to separate the detached hulls, or chaff, from the grain by winnowing. The usual way is to scoop the trampled mass into a shallow basket and toss it into the air above a mat or sheet. The heavy grain falls straight down, while the chaff is floated to one side by the gentlest of air currents.

For the most part the hulled grains of rice are not white but are covered with a coat of brown, which can be removed by rubbing or beating, a process called "polishing." However, many native rice-growers dispense with this procedure and eat "brown rice" instead. The food value of rice is decreased by polishing, yet custom regards white rice as preferable.



TRANSPLANTING RICE. Sometimes the seed is sown broadcast, sometimes it is trampled into the mud. Here the young plants are being replanted, near Baguio in the Philippine Islands

A.M.N.H. photo



MULTIPLE SCARECROW: an arrangement of lines extending to all portions of the field and jerked as needed from a central tower. This device is used frequently in Hawaii. Constant vigilance is necessary to save the rice crop from birds

Sevda Studio photo

WHEN the field is dry and the rice mature, knives or sickles are used to harvest it. A scene in Bali

Photo by Lionel Green, from Frederic Lewis





A Japanese rice garden

Three Lions photo

In the Philippines, as in many other parts of the rice area, hillsides are utilized by the construction of terraces, or walled-in shelves, extending horizontally one above the other. These are flooded with water in the rainy season. The magnitude of these terraces, covering the landscape from valley to hilltop like a gigantic series of hanging gardens, is impressive. The prodigious task of keeping them in order means that the owners make rice-growing their chief concern. Hand labor prevails, with the simplest mechanical appliances,—little more than digging sticks, crude wooden shovels, and the bare hands. The plow, first developed by wheat farmers, seems to have been introduced by the Spanish conquerors of the Islands.

Since 1500 A. D. the cultivation of rice has been introduced into many tropical and semi-tropical areas, such as southern Europe and North Africa, and parts of west Africa,



Heavy wooden pestles are sometimes used in hulling rice in the Philippines

Theodore Roosevelt, Jr. Collection, A.M.N.H.

eading rice in the Philippines: aboriginal method of threshing he world's staple food grains

no Jacobs photo, from Three Lions



After the rice is hulled, it must be winnowed. The kernels fall to earth and the chaff floats away

Alfred T. Palmer photo, from Black Star

Fenno Jacobs, from Three Lions

BEATING RICE to separate the kernels from the husks, in the Philippines

THIS VIEW in a Chinese shop in the town of Pishan shows a method of hulling rice that has been in use for centuries

Alexanderson (C N S), from Guillumette, Inc.



UNHULLED RICE KERNELS





THE LABOR OF TENDING HILLSIDE RICE TERRACES like these and of keeping the dikes in repair can easily be imagined: a scene in Ifugao Subprovince, Luzon, in the Philippines, where human life revolves about the growing of rice

Theodore Roosevelt, Jr. Collection, A. M. N. H.

southern United States, certain localities in Mexico, Central and South America, and many Pacific Islands, including Hawaii. The annual production of rice in the United States is about 70 million bushels, or about one-fourth the barley crop. This amounts to about one-half bushel per capita, but since cooked rice expands 300% in bulk, the amount is of some importance.

North American Wild Rice

Our story would not be complete without some account of wild rice in America. This is a different genus of rice, *Zizania aquatica* and *Z. milicea*. *Aquatica* grows in single stems, five to ten feet tall, with panicles about two feet long. The glumes (husks) are about an inch long, containing long slender grains, of a dark slate color when ripe. The plants can adapt themselves to quiet water, two to eight feet in depth, preferably the margins of ponds, lakes, or flood plains of rivers with mud bottoms. Early in June the shoots appear above the water. They mature about August 1st, and the grain is ready for gathering in September. The early French explorers speak of this wild rice as wild oats, Indian oats, etc.

The plant is an annual and seeds itself, since the ripe grains are heavy and sink to the bottom when they fall. The main habitat of *Z. aquatica* is the part of the United States and southern Canada east of the 100th meridian west, an area roughly east of a line passing through Pierre, South Dakota, Dodge City, Kansas, and Abilene, Texas. The Indians who made the most use of wild rice were those of eastern Canada around the



WILD RICE, NATIVE TO NORTH AMERICA, was an important source of food to many Indians. It flourished without cultivation in the margins of lakes and on the muddy floodplains of rivers and was harvested in September. (Potomac River)

Fish and Wildlife Service photo



CHIPPEWA INDIAN in boat, tying wild rice. To protect the rice from birds and wind, the Indians laboriously tied the heads in bunches. Ducks of every variety, geese, and birds of all sizes and kinds found millions of acres covered with this pleasant food, while the Indians could gather but a small quantity, according to Mrs. Eastman, who described the aboriginal scene in 1853

Courtesy of the Bureau of American Ethnology



THE BINDING TWINE was threaded through rings attached to the jacket the woman wore when tying wild rice. From two to six miles of twine are estimated to have been needed by each family for tying one season's wild rice. Customarily the twine was made by shredding out long slender ribbons of basswood bark fiber and tying them together (From the Chippewa Indians)

Photos courtesy of the Bureau of American Ethnology

Great Lakes and Winnepeg drainage areas, tribes speaking Algonkin and Siouan.

A similar Asiatic species, Z. *latifolia*, has been observed in Siberia, Japan, Formosa, and part of eastern China. Although Z. *aquatica* is reported from the West Indies, it is not known in South America.

None of the North American Indians seem to have *sown* wild rice until after contact with white people. Since 1800, some of them are known to have stocked lakes and ponds when necessary, but once the plant was introduced, it needed no cultivation.



A NARROW BED of wild rice tied in bunches or sheaves



THE PROCESSING OF WILD RICE in America was in many ways similar to that of cultivated rice in the Orient. Here we see a Chippewa Indian treading rice in the familiar manner to remove the husks, but with two railings to take some of the weight off his feet

Courtesy of the Bureau of American Ethnology

The only attention the early Indians gave the crop was to tie the rice heads in bunches to protect the crop from birds and to prevent the wind from shattering out the grains. For this, they made twine of basswood bark fibre. Each woman, or family, used a slightly different tie and accordingly claimed ownership of the ripening rice.

The rice was gathered from canoes, poled or paddled among the rice stalks, the bunches of heads being bent over and the grain beaten off into the boat, as shown in one of the illustrations. The earliest accounts of rice gathering (1689) mention tying the heads but make it clear that much of the rice harvested was not tied but merely bent over the edge of the canoe, as shown in the drawing by Eastman. When a canoe was filled, it returned to camp, where the load was spread upon drying-frames.

The grains had then to be hulled by treading or beating. According to tribal custom, there were varying stages in these processes, since the drying frames might be smoked, the grains parched in a kettle, etc. The wild rice you purchase from your grocer has a smoky flavor if prepared in the Indian way.

Note that the main procedures in preparing wild rice closely parallel those for cultivated rice in the Old World. The two important differences are that in Asia rice is not tied in bunches to protect it from birds as was wild rice in America, and it is not smoked. On the other hand the American grain is not polished. In both areas the laborious processes are harvesting, hulling, and winnowing the grain. Like the Asiatics, the Indians almost never ground their rice but ate it boiled, usually with meat of some sort and frequently sweetened liberally with maple sugar. The Indians did not plant and

WHEN THE WILD RICE was ripe for harvest, the grain was beaten into canoes as shown in this drawing by General Seth Eastman, dating from the middle of the last century. To quote from Mrs. Eastman, the girls from an Indian village made quite a frolic of it

Eastman's Aboriginal Portfolio



weed their crops, but the labor of making twine and tying their rice was by no means a light task. Gathering the basswood bark and preparing the twine by hand occupied the spare time of the family during the winter months. We have estimated that from two to six miles of twine were needed by each family, the number of bunches tied ranging from 400 to 1600.

Indian Corn or Maize

The first human beings to discover America were primitive stone-age hunters from Siberia. The time was late Pleistocene, when the last of the huge elephants were still tramping through the swampy parts of North America; camels, wild horses, and tall long-legged bison could yet be seen in the

A.M.N.H. photo



WILD RICE from the country of the Ojibway Indians: above, threshed but not hulled; below, hulled and ready for storing or cooking

open grass lands, and the giant sloth was using caves as burrows suitable to his size. Other kinds of game more modern in character were there in plenty. Up until that moment none of these American animals had ever seen human beings, so they were ignorant of man's predatory nature.

Once in America, these invaders found themselves in a hunter's paradise, free from enemies of their own kind and surrounded by game easy to approach. The animals were similar to those of their homeland, but the plants were for the most part strange, inviting experimentation to learn their uses and dangers. All of these new objects and freedoms stimulated the savage mind; food was abundant, so the population increased rapidly. When a band of hunters became too large it divided, and the new band moved into the unoccupied country ahead. Old vocabularies were discarded and new words invented to designate new objects and relations. The tempo of life and health was stepped up. At least, this seems a reasonable expectation.

No wonder anthropologists found about 1500 different languages spoken in the New



A In 1920 a quantity of ancient fodder was found in the ruins at Aztec, New Mexico, dated about 1120 A. D. by the tree ring method of chronology. During the lunch hour, one of the mules belonging to the workmen ate a large part of the fodder before discovered in the act. The ear marked A at right is one of the pieces from that cache

OTHER TYPES OF MAIZE IN THE EAR

B Pre-Columbian maize, fourteen rows of grains to the ear, in spiral. (From Arica, Chile)

C Modern maize, eight rows. Pawnee Indians

D Modern maize, eight rows. Iroquois
E Modern maize, eight rows. Pueblo, New Mexico

A.M.N.H. photo

World, and though linguistic experts have been able to group these languages into about 175 families of speech, they have been unable to be sure of genetic relations between any of these families. Again, those who study the ways of living, customs, and habits of the many hundred surviving tribes of Indians, find them of great variety. The new methods devised by archaeologists are revealing that rapid changes occurred in ways of living even in the same localities, far too rapid to be correlated with changes in climate and other ecological phenomena. In the main, this welter of detail will be found consistent with the expected adjustment of successive generations of hunters to the changing local environments besetting their migration routes.

As the hunters spread southward, every now and then a favorite plant food would not be found in the next strange locality. Thus new problems would arise, such as: could plants be moved? When the Andes were reached, large game was probably less plentiful than formerly, but plants did not decrease, merely changed in kind. From a survey of the plants domesticated many botanists favor the Andean highlands as the place where good wild plant foods were most abundant and where newcomers would therefore find the greatest incentive to experiment in agriculture.

That maize was the first plant to be cultivated is unlikely but its wide distribution testifies that, once it was on the way, its merit was obvious. Certain caves in Kentucky and Arkansas have yielded evidence that agriculture was practiced long before the earliest appearance of maize in their deposits—for example, seeds of the domesticated sunflower, the giant ragweed, etc. Nor is it likely that any single plant can be proved to have been the first. Conditions being favorable in many localities, there may well have been spontaneous independent experiments with different local species of plants in different sections.



From the Codex Florentino

NATIVES of the Western Hemisphere did not know about the plow when Europeans arrived. Digging sticks and spadelike implements were the universal New World agricultural implements. This illustration is an Aztec drawing showing a farmer planting maize with a digging stick. The traction plow is an Old World device, assumed to have evolved from the digging stick



White maize grown by Iroquois Indians about 1905

List of Native American Plants of Economic Importance

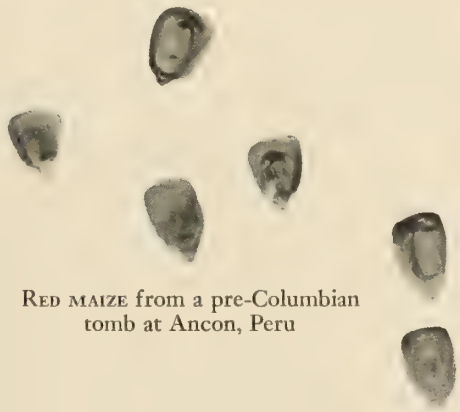
CULTIVATED

maize	potato
tobacco	peanut
manioc	sweet potato
pumpkin	tomato
cotton	sisal
avocado	pineapple
beans	chocolate
calabash	coca
chili	sunflower
ragweed	pigweed
barnyard grass	cashew nut
maté	cinchona

NOT CULTIVATED

rubber	pawpaw
copal	plum
Indian hemp	water lily
nettle	camass
basswood	mesquite
wild rice	acorn

That the Indian eventually selected food plants of extraordinary qualities is evidenced by the world-wide use of maize, the potato, bean, peanut, squash, cassava, pineapple, etc. The Old World can scarcely rival this list. So quickly were many of these carried to all parts of the world that it has been difficult to prove their New World origin, except by noting that their obvious wild ancestors were not found outside of the New World. Thus in Europe maize was first called "Turkish corn or wheat," for the same reason that the native poultry of the Aztecs is called *turkey*, even in America, because these foods were quickly adopted by the Turks and from thence introduced into Europe. In the same way, the name "Irish" potato concealed for a long time the South American origin of that important food.



Red maize from a pre-Columbian tomb at Ancon, Peru

Indian Methods of Growing Corn

When discussing wheat we noted that a general pattern of procedure prevailed from ancient times to the present. The same is true for corn. Everywhere within the corn growing area the Indian pattern was the same in outline, the sequence of processes were preparing the soil, planting the seed, protecting the crop, gathering the ears of corn, storing, grinding into meal and selecting the seed for the next planting. The usual tool for preparing the soil and for cultivation was the digging stick, in some localities taking the

form of a foot-plow, a spade, etc., but in parts of the United States a true hoe. Everything was hand work. The universal method was to plant four or five grains of corn in a hill, or at intervals in a ridge, except in very dry regions where the planting might be in holes or trenches.

It is curious to observe how closely white people, settling in America, copied the Indian methods of corn farming. They speak of the Indians as savages but still use their methods of growing and using corn.

Our farmers formerly planted, and often yet plant, maize in hills; this was the universal Indian mode, four or five grains being dropped at one place at regular intervals of about three feet, quite like a cornfield of today. In cultivation, the Indian hoed the earth up around the growing stalk, which is still the principle of the mechanical cultivator. For husking, our farmers use a husking pin, which, while now of iron, was not so very long ago of bone or wood, precisely like those still in use among our surviving eastern Indians. Ears of corn to be dried or preserved for seed often have their pendant husks braided together; this is typically Indian. The corn crib was used by the Indians and elevated on posts to keep the contents dry and to protect it from rodents. The type of

A MANDAN INDIAN GIRL of about 1700 A. D. cultivating maize with a hoe, made of the shoulder blade of a bison. The history of the hoe is obscure. In the New World it had a limited distribution in eastern United States but was unknown in our southwest, Mexico, and South America

Statuette by Paul Wright, in the American Museu





AN ANCIENT CORNFIELD UNCOVERED. Skillful excavating permitted archaeologists to expose the wavy surface several feet underground representing the orderly ridges of earth. This field was tilled by prehistoric Indians on what is now the Ocmulgee National Monument, Macon, Georgia. The early people later buried the field while landscaping for a ceremonial building

National Park Service photograph

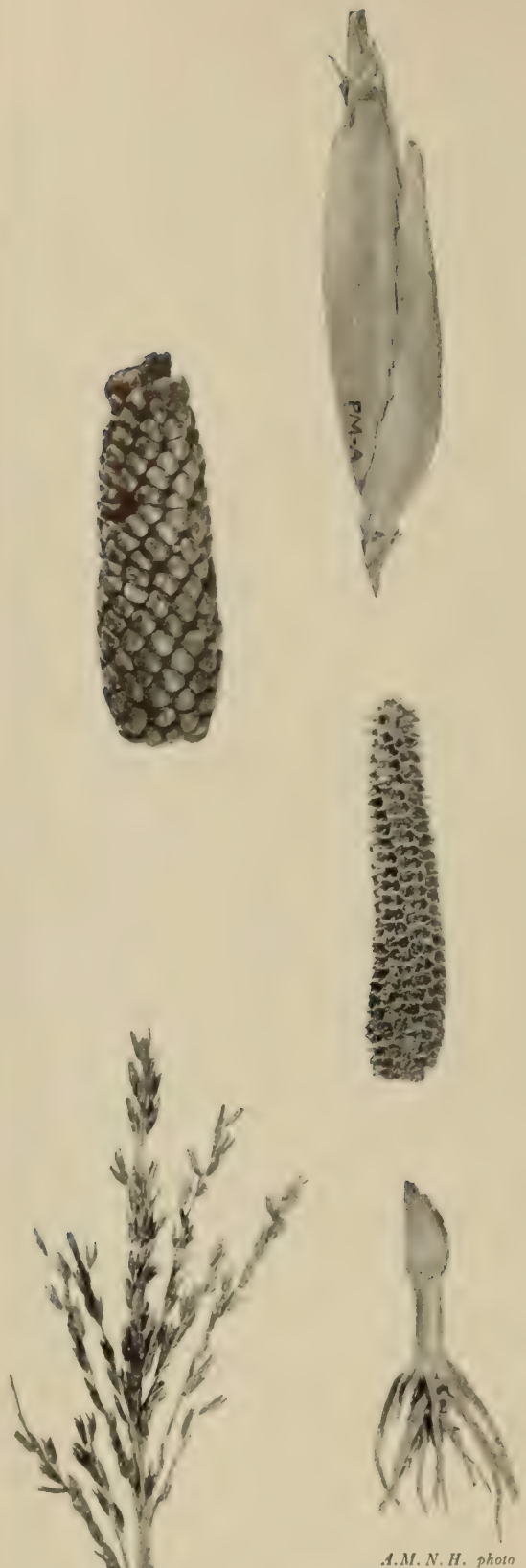
crib which is larger at the top than at the bottom was also in use by the southern Indians.

The Indian planted beans and squashes among the corn. This has always been a favorite custom of our farmers. He also understood the art of testing his seed and of preparatory germination in warm water. Where fish were available they were used for fertilization, the rule being one fish to a hill.

The methods of cooking corn are not only still about the same among us, but we also retain many of the Indian names for such dishes, as hominy and succotash. The famous roasting ear in all its forms was known to the Indian. Then we must not forget the favorite mush, which is stirred with a wooden ladle

RANGE IN SIZE at one time and place is shown by these ears from the largest and best preserved cache of pre-Columbian maize ever found. The collection was discovered by Earl Morris in 1923 in Canyon del Muerto, Arizona. It was in a stone cavity tightly closed by a slab of sandstone, in the floor of a rock shelter. The several hundred ears are dated at about 500 A. D. and differ from modern pueblo Indian maize in color and size. They resemble old pre-Columbian types in South America. The grains are dark red, 10 to 14 rows to the ear, mostly straight but some spiral





A.M.N.H. photo

EARLY PRE-COLUMBIAN MAIZE excavated by Junius Bird near Arica, Chile, showing tassel, root-node, ear, husk, and cob. Corn was cultivated many centuries ago and over a wide area in North, Central, and South America. But it was probably not the first agricultural product in the Western Hemisphere

strikingly like those of the Algonkin tribes. Some years ago our country people still made "lye hominy" with wood ashes, just as described by some early observers of the Indian.

Corn-husk mats may still be seen in some country homes. As I recall a few specimens examined, the technique was the same as the Iroquoian examples to be seen in our museums.

The one important innovation of the white man was the substitution of the mill for the mortar. Later, of course, came various kinds of machinery for the cultivation and gathering of corn, but all such machines are mechanical appliances to perform more expeditiously the same old processes. It is clear that in pioneer days the white farmer took over the whole maize culture-complex entire, except its ceremonial and social elements. Even here we find some curious similarities. The husking-bee, which was one of the great social events of our fathers' times, is strikingly paralleled by an old Indian custom. No doubt if we knew more of the homely history of our forefathers we should find some surprising intrusions of ceremonial and superstitious practices to propitiate the growth of their crops.

If we reduce these data to a generalization, it appears that the white colonist took over the entire material complex of maize culture. He did not simply borrow the maize seed and then in conformity with his already established agricultural methods, or on original lines, develop a maize culture of his own. In fact, he has no basis for any claims to originality except in the development of mechanical appliances and the somewhat recent rationalization of agriculture by scientific investigation.

In this connection the maize culture of the Old World is particularly suggestive. At the discovery of America, samples of maize were carried home, seed was planted, and in a surprisingly short time its cultivation spread even so far as China; but the maize complex of the Old World has scarcely anything in

common with that of the Indian and the American farmer.

When the seed of corn reached Old World farmers they considered it a cereal, which was correct, and accordingly followed the pattern for wheat and other cereals, sowing it broadcast so that the plants stood thick and crowded like wheat. The result was that the ears were small, but the crop made splendid stock food. People did not eat the grains because the meal did not make good bread like wheat. In World War I, the United States offered to send starving populations corn for making meal, but these well meant offers did not appeal to them; they did not

THE CULTIVATED BEAN is of New World origin. Two types grown in pre-Columbian times are compared here with a modern type
(a) Kidney beans from Surco, Peru
(b) Lima beans from Surco, Peru
(c) Kidney beans, Iroquois, about 1905

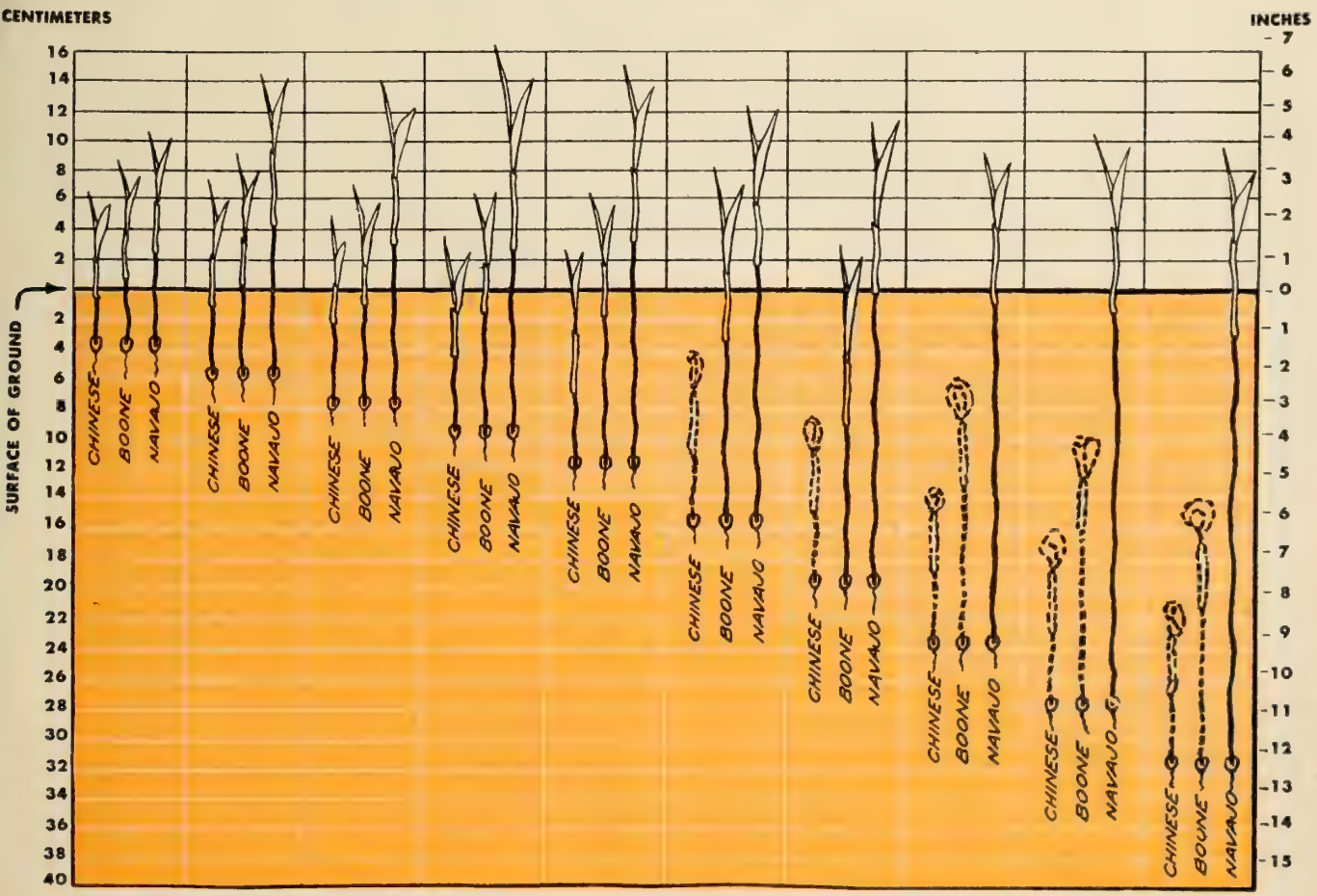


a b c

A.M.N.H. photo

SUPERIORITY OF NAVAHO MAIZE FOR DEEP PLANTING

PROOF that Navaho corn is adapted to planting at a depth of more than one foot (32 cm.). The type was developed by artificial selection for planting deep enough in dry sand for the roots to reach the yet deeper moist ground



After G. N. Collins, courtesy The Journal of Heredity

like cornbread and anyway we were offering them live-stock food instead of plain necessary wheat bread.

The reason is plain—it was the isolated plant that came into European culture, necessitating original experimentations with the new seed, or, at least, the adaptation of its culture to the methods or "patterns" for the raising of other plants. The first American farmers, on the other hand, found themselves projected into the midst of a new culture, where it was much easier to adapt trait-complexes than to invent them. It is more than likely that we are here illustrating two characteristic modes of culture diffusion: in one case a new object or an isolated idea is carried far afield and dropped into the midst of a strange culture group, and in the other the group itself is dropped into the midst of a strange culture, or merely brought into contact with it. In the latter, whole complexes will be taken bodily; in the former, a new trait will be originally developed or simply adapted to some already existing pattern.

The Weak Development of Animal Industry in Aboriginal America

That the farmers of the New World made the most of plant exploitation is clear. The intruding white population did not discover a single wild plant of outstanding economic importance not recognized and used by the aborigines. Even rubber was gathered in the Amazon country and produced in Mexico from the dwarf guayule plant.

The aboriginals were aware that animals could be tamed, but they failed to grasp the idea that the propagation of animals for their flesh was feasible. And in animals for traction the aboriginal score stands at zero. Was this due to blindness as to the virtues of the wheel or because suitable traction animals were



A.M.N.H. photo



RAPID TRANSIT by manpower in old Peru: a jar and the drawing that decorates it (*below*). The drawing shows a dignitary surprised by unexpected guests, perhaps officials with captives from "the front." The dogs on the roof are behaving normally



Representations of corn on Peruvian pottery of the early Chimu Period, about 500 A. D.

lacking? When we note that in ancient Mexico toy animal figures were made mobile by small wheels, the mystery deepens. The more primitive tribes in the bison area of the United States and the Eskimo of the Arctic used dogs for traction, the former with the travois and the latter with sleds in winter. The Aztecs had no burden-bearing animal; the Inca used the llama, which could carry a load of about 90 pounds. That tells the story. It is a poor showing in contrast to the ancient Old World with oxen, asses, horses, camels, elephants, etc., able to draw heavy loads and carry one or more persons upon their backs. The Aztecs were doomed to carry freight upon their own backs: the roads to Mexico City were lined with carriers, many with huge packs upon their backs for delivery to the Aztec tribute gatherers. Now and then came a trader with a troop of carriers, but most frequently men and women carried goods individually to market in the towns. Within the City of Mexico were numerous canals and then the lake, crowded with canoes similarly loaded, but over the country at large, freighting between cities and towns was back-breaking drudgery. Some of the rich were carried in litters, but most people walked, burdened with baggage.

We have praised maize as a cereal fit to implement a civilization, yet as a food, wheat makes a strong claim for being the No. 1 world's cereal. Above all it is still the leading source of bread. Maize was a good substitute, but its modern popularity rests upon its value as a stock-food. The weak point in Old World animal husbandry was the want of a satisfactory stock-food, but the world was quick to discover the superiority of maize for animals. So let us give the aboriginal American his due. He may have a poor record in the integration of agriculture and stock raising, but he compensated for it by contributing to the world the ideal stock-food, thereby bringing about an almost ideal integration of agriculture and animal husbandry, the one basic principle in maintaining modern civilization.

Origin of Maize

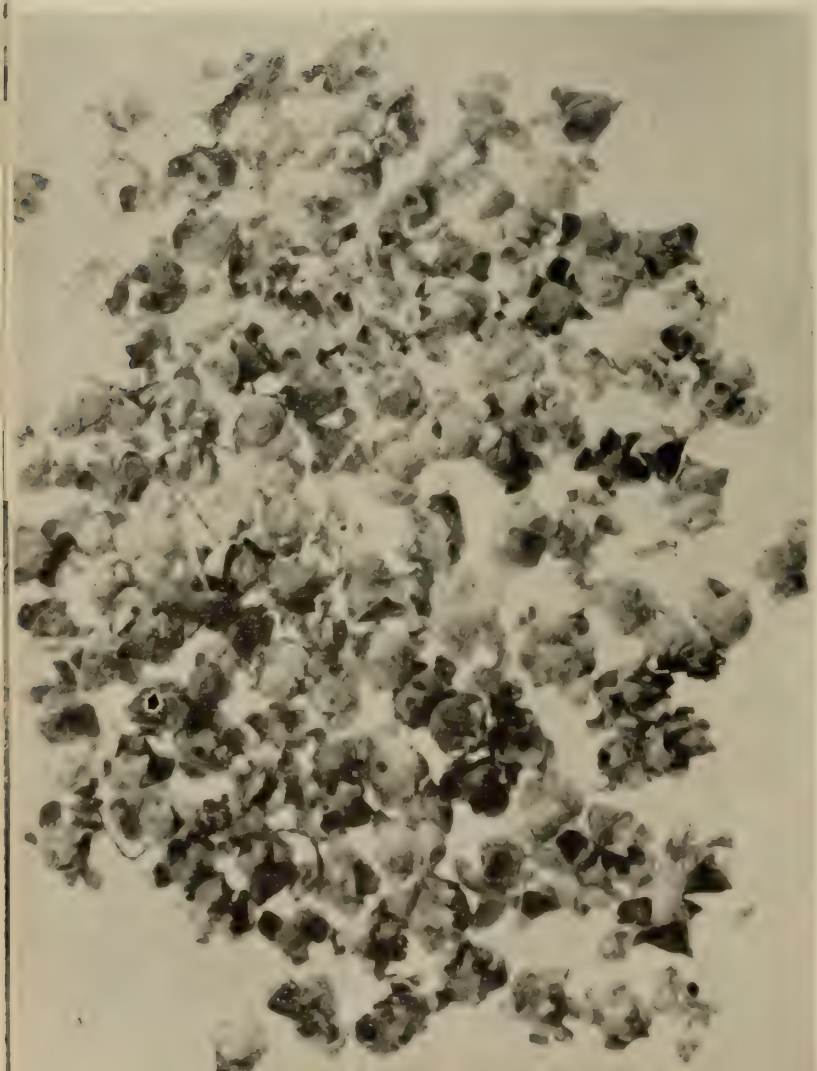
The wild ancestor of wheat was not discovered until about 1900; and as for maize, no wild plant has even yet been found which qualifies unquestionably as the original ancestor. The leading contestants for the honor are:

Teosinte (*Euchlaena mexicana* Schrad.)
Tripsacum (*T. dactyloides* L.)
Pod Corn (*Zea mays tunicata*)

Neither cultivated maize (*Zea mays* L.) nor Pod Corn has been observed able to propagate itself in a wild state. Neither do the traditions of Indian tribes nor early colonial documents give much help in recovering the lost history of maize. The first explorers found it grown from Maine and Quebec on the north, to Florida on the south, in the Mississippi valley, in the West Indies, in the lowlands of South America, in the Andes, and as far south as Patagonia. Archaeology has proved its antiquity in our Southwest, Mexico, and the Andean countries (*see map p. 39*).

Perhaps no other domestic plant has been subjected to as much exhaustive botanical research as maize. Many experimental agricultural stations have made such research a major part of their respective programs, a large fraction of which have been concerned with a search for wild ancestors, because of the need for a clear understanding of maize genetics. Yet the mystery remains. However, the intricate detailed knowledge of maize chromosome patterns does make some suggestions. The tendency now is to assume a South American Andean highland origin for its first cultivation, and so prevails the still unrealized hope for finding a wild ancestor somewhere in that area.

Maize is regarded as a grass, prone to cross with a wide range of other grasses. Further, domestic maize still reveals flexibility to environment, rendering its specific adaptation to local conditions easy.



THE OLDEST KNOWN POPCORN. The well-popped grains were still fluffy white when found in the adjacent bag attached to the belt of a mummy in Chile. The popcorn was probably left as a mortuary offering. The horny shells remaining show that the kernels were deep red



A.M.N.H. photos

On the other hand, the original Indian type of maize possesses a vitality equal to the preservation of its essential qualities, even though cultivated for centuries by the more primitive hunting tribes of the marginal maize areas. The surviving modern types were produced from seed originally taken directly from Indians in eastern United States. The several recognizable modern varieties are:

Pointed popcorns
Dent corns
Flint corns
Flour corns
Sweet corns

The latest theories about the origin of maize are chiefly of two types:

(a) that it originated in Guatemala in the cultivation of a wild grass, teosinte or tripsacum;

(b) that the Andes was its home and that the ancestor was a form of wild pod corn not yet identified.

The modern approach to the solution of the problem is through the study of chromosome patterns in the germ cells. The most recent work by P. C. Mangelsdorf and his students suggests that the earliest form of maize was propagated in South America as a hybrid, which spread throughout the Andes, finally reaching Central America; there it was again crossed with a related wild plant, finally reaching into the valley of Mexico, where once again it crossed with a wild grass. Thence, some of this seed passed into the West Indies and southern United States, to be returned to the Andean highlands, all in pre-Columbian time. The arguments used in debating these theories are too technical to be understood by anybody except a few experts in the genetics of modern maize.



Pod corn, one of the three contestants for the honor of being the ancestor of maize, here shown in a pre-Columbian ceramic replica from Peru. Each grain has a separate husk as is usual among grains. But pod corn has never been observed to propagate itself in a wild state

The Geographical Setting

We noted that civilization in the New World began in the central part of the land mass (*see map*). Mexico, Central America, and the Andes highlands are neighboring regions. However, if we look at separate single complexes of living habits, some of



Thumbnail sketch of the area in which city-states prevailed, including the Aztec and Inca nations, with outlying areas. This map is also the key to events since 1492. Spain had the lead in exploration, so seized all of area A. England finally came to control all of B and C in North America, and Portugal most of B2 in South America. The independence of the United States and countries to the south explains why we have two Americas—English-speaking America (Canada and the United States) and Latin America (Spanish- and Portuguese-speaking countries to the south)

them will show a wider geographical distribution than others. For example, the cultivation of maize in 1492 will show a wider distribution than many other traits of the Aztecs and the Incas.

Further the simple map we present tells the story of the evolution of society in the New World as of 1492. The two great city-states, Mexico City and Cuzco, ruled over the greater part of area *A*, comprising in all many smaller cities and towns more or less subjected. The boundaries between Inca and Aztec lands did not overlap but were widely separated in Colombia and Central America by intervening towns and cities. Area *A* on the map defines the region of intensive culture and the sphere of influence of the Incas and the Aztecs in 1492.

Thus this crude little map not only tells what happened here before 1492 but is the key to what happened since. It seems to make the fundamentals of American history so plain that one pauses in astonishment that the teaching of history even in our elementary schools should not have adopted this device from the first. Our grandfathers were fond of the expression "a thumbnail sketch;" this is an illustration of what they had in mind. If the reader has been able to grasp the significance of this map, he need not be a specialist in American history to "know where he is at."

What Might Have Been

Almost everyone who reads a short account of the evolution of these New World civilizations, spontaneously frames the same question: If Columbus had failed and America had remained isolated for another 2,000 years, what would have happened? Attempts have been made to answer this question. It is inconceivable that no advances would have occurred. On the other hand, the discovery of America was inevitable, because Europe had awakened, ships were at hand capable of long voyages, the idea of the rotundity of the earth was not only accepted by many learned contemporaries of Columbus but the proofs of the theory were considered sound. At most two more centuries would have brought the solution to what lay beyond the western sea. So such speculation is futile.

Summary Comment

WE HAVE now passed in review the three outstanding cereals of the world. First let us attempt a comparative view of wheat and corn (maize). Each seem to be a fundamental trait in a pattern of civilization. Yet the American aboriginal pattern of Middle America and the Andes had few new traits to contribute to the Old World pattern, except a number of domesticated plants. Relatively these were no mean contributions to modern diet and economics, as we have stated. Human life is so varied and rich in detail that we often despair of discovering a simple scheme of classification realistic enough to be useful, but one of the most satisfactory in the sphere of human geography is the recognition of the three great cereal areas, wheat, rice and maize.

Minor Cereals

To acquire a more complete picture of man and his cereal foods brief note should be taken of a few of the best known secondary food grains. Curiously enough, for the most part these are submerged in the over-all pattern of Old World civilization, seemingly originating in parts of the great wheat area. (Map p. 17) We defined that pattern as embracing such elemental general concepts as cereals, plow, wheel, writing, etc. In time rice came to dominate an area of its own, apparently due to environmental conditions, but otherwise the civilization pattern was generally similar for the Old World as a whole. Yet the totality of the New World pattern embraced minor cereals, also, which were not taken over in a large way by the Old World civilization, as in the case of

maize, and a few other cultivated plants, such as tobacco, beans, etc. Among the New World domesticated grasses, whose seeds could have become minor cereals, were barnyard grass, the giant rag-weed, pigweed, sun-flower, etc., yet they did not successfully compete with rye, oats, buckwheat and millet either as stock food or cereal substitutes.

Millet

The millets of the present and of antiquity comprised a variety of grasses of different genera, including the sorghums and Kaffir corn. What appears to be the original millet (*Panicium milaceum*) appears archaeologically in the ancient wheat area. At Ur it appears before wheat and barley. Chinese traditions give millet priority over wheat. Its cleaned seeds are found in the remains of the Lake Dwellers of western Europe and it was known in Mediterranean countries during Greek and Roman times as contemporary to wheat and barley. It spread into Egypt and North Africa and the sorghums penetrated deeply into central and south Africa. Millet was known in India and parts of southeastern Asia. The tendency is to consider millet the first grain to be domesticated and so to have priority over wheat. It did not reach America until after 1500 A.D. where the various plants passing under that name are grown as livestock foods.

In the Old World the plow is possibly older than wheat; if so, its invention may be credited to the millet farmers. Chinese tradition seems to regard the millet farmers as the originators.

Barley

Barley is one of the ancient cereals, possibly older than wheat since it appears in some ruins before wheat. It was known in China before 2800 B. C. but possibly not before wheat. Anyway barley competed successfully with wheat which reached China at about the same date. Of course, the invention of yeast bread put barley second on the preferred list, but it has survived as a food and today is preferred for beers and ales. As a rule it matures earlier than wheat. Bread of a fashion can be made from its flour, but cracked it can be boiled and served as a gruel. In colonial times it was a favored food in the middle Atlantic Provinces. Even now it is popular in broth. In South America the surviving Indians of the Andean countries raise it because it gives a crop earlier than maize or wheat.

Rye

The origin of rye is obscure but the wild plant has been observed in many parts of the north temperate Old World. It is hardy, thriving at high altitudes, and has not been sufficiently domesticated as to prevent its running wild. In Europe it was called "black-wheat," probably because the grains are dark. They are usually smaller than wheat. When wheat was planted in unfavorable latitudes and altitudes, rye often intruded, surviving even when the wheat sown failed to make a crop. It is possible that the cultivation of rye began in this way. However, its appearance is relatively late so no claim for priority is made for it. As we have stated rye makes passable bread, but black and heavy in contrast to wheat bread. In America the tendency is to mix wheat flour with rye, thus making the bread lighter in color and weight. In northern Europe where rye can be raised more easily than wheat and barley, its bread is known as "black bread." In late historic times rye has been in demand for distilling liquors. Its straw, also, is superior for thatching and braiding.

Oats

Oats is a general name for a family of grasses many of which are still undomesticated. Its domestication is not ancient and the tendency is to regard it as the youngest of

the cereals. In the main oats is valued as a live-stock food, both for grazing and feeding as a straw and seed crop. The husks of oats adhere to the grain similar to rice, and when used for human food, oats must be hulled by special processes, and crushed (groats) or ground into meal. The country first specializing in the use of oats seems to have been Scotland, though great quantities are produced in the United States and Canada, chiefly for horse food. Yet under the name oat-meal it is one of our best known breakfast cereals. Oats grows best in northern latitudes, can be sown early in the spring and matures quickly.

Buckwheat

Buckwheat was probably first domesticated in China at a remote date and was grown in India, where one species seems to be native. However, the common buckwheat was wild in southeast Russia, west and central Asia. Apparently it came into western Europe through Germany, its German name being *Buchweisen*, so designated because the seed is shaped like a beechnut. In England and the United States the name was corrupted into buckwheat, probably because it was a possible substitute for wheat. At this point attention may be called to difficulties the first settlers in the United States encountered in attempting to grow wheat. New diseases attacked the growing wheat against which the plant had no acquired immunity, the result being such frequent failure of crops, as to force the colonists to find substitutes. The natural recourse was maize as grown by the Indians, hence it is understandable why corn-bread and hominy became the chief pioneer foods. Even when wheat survived the yield per acre was much less than for corn or maize. Buckwheat gave a high yield and was not troubled by disease. Also it was quick growing and its food value high. Another distinct advantage was that the



A SEED-GATHERING BASKET AND BEATER from the Paiute Indians of Nevada. The basket is shaped so that the edge can be held low and the grass stalks bent over it and shaken by the beater. Again, the beater may be used to catch falling seeds and transfer them to the basket



Iliawra women in Australia collecting grass seed from ant's nests

All of the world's modern production of wheat, corn, and rice has grown out of the primitive occupation of collecting grass seed. Today we can still see this elementary activity among the naked, hungry Australian "blacks," as shown in these drawings. For thousands of years, primitive women have thus gathered food—a seed or two here, another there—at great cost in toil and patience and with a return so trifling as to transcend belief

gluten content of buckwheat flour was sufficient to make yeast bread.

So we find buckwheat a popular crop in New England, New York, Pennsylvania and the northern tier of states. Furthermore, it is quick growing and therefore popular in Canada. Another advantage lies in its value as a live-stock food. Since 1930 production in the United States has declined rapidly, but it is still popular for griddle cakes. In the Ohio valley farmers soon learned that barley was ready to harvest before wheat and that if buckwheat was sown promptly it would mature before frost and thus the same field could produce two crops in one season.

The Gathering of Wild Seeds

It is logical to conclude that a long period of subsistence upon uncultivated seeds preceded all attempts to domesticate seed plants. Looking backward over these pages it appears that the period during which man merely gathered the wild foods that nature offered at the time and place, without cultivating the plants, was by far the longest span of time in human existence. During this long primitive period man overran all the habitable parts of the earth and met up with almost every variety and species of seed-bearing plants. The opportunity for experiment was almost boundless. In turn, the habitats of these grasses were spotty and highly localized. By trial and error; man probably came to recognize the most important species of seed-bearing plants in his habitat and sought to devise more and more convenient ways of gathering, processing, and cooking them.

Even from the first he seems to have been a *gourmet*, putting himself to a bewildering routine of trouble and toil to improve the

Treading the grass seed to husk it

Winnowing the husked grass seed

Drawings by Paula Hutchison, from photographs

The simple but exacting routine of converting grass seeds to food is everywhere the same: (A) find the ripening seed, (B) strip the grain from the stem, (C) hull it by treading, (D) winnow out the chaff, (E) pulverize the seeds, (F) combine with water to form a paste, (G) bake or toast on a fire



According to one theory, manioc was the first plant to be domesticated in the New World. That it is a good food for man and beast is clear from its popularity and wide modern use under the names cassava, sago, and tapioca. It is easily cultivated and well suited to people on the level of a hunting economy. Originally grown in eastern South America and the West Indies, it has been introduced to the natives of tropical Africa and other parts of the Old World. Civilized peoples grow it for stock-food where the climate is suitable. The root is pulverized and dried, providing a good cereal substitute

A.M.N.H. photo

raw products offered by nature. His fellow creatures were content to take seeds as they found them, but not he, as in the words of the most ancient of sages, "He prefers to earn his bread by the sweat of his brow." Even the way of the savage is the hard way. Hours and hours of patient toil are given to the preparation of what is eaten in a few minutes.

Fortunately for us, not all peoples of the earth became civilized at once. The understanding of our subject is made possible by comparing the ways of the nonagricultural peoples with the civilized. Thus in the United States we can still observe Indians gathering seeds as they did centuries ago, particularly in the semidesert lands of Arizona, Utah, Nevada, and southern California. The Paiute tribes, armed with simple ingenious basketry devices, strip seeds from many species of wild grasses, winnow out the chaff, and store the tiny seeds for grinding into meal and eventually baking in cakes, or more frequently for thickening soups. Seeds of more than 50 species were gathered by the Paiutes alone, which about exhaust the list of local wild grasses. Civilized men and women will not bother themselves over such small returns for the labor involved.

In a large part of semiarid Australia, where there is sparse vegetation and grasses, it is not surprising that the natives recognize the food value of even the smallest seeds. They carefully gather and conserve them, grinding them between stones and making cakes with the meal. It should not be overlooked that arid lands also bear numerous root plants whose bulbs are dug out with digging sticks. This is true in Australia as well as in the habitat of the Paiute Indians of the United States. Thus the popular contemptuous name "Digger Indians" is said to have been applied to many tribes west of the Rocky Mountains because they were so often seen digging in the ground for food. Some Australian explorers have written that the ground around a native encampment was so upturned as to suggest that a drove of pigs had been rooting up the place. Even Captain Lewis (of the Lewis and Clark Expedition) found the Nez Percé Indian women who were camped along the Columbia River so busy pounding roots that the noise reminded him of a nail factory.

But we are now concerned with cereals or seed grasses. We have reason to suspect that a long period of experimentation with wild seeds was necessary before success was achieved in producing the world's three great staple foods—bread, (wheat, barley, and rye), hominy (maize, hulled by boiling in wood ashes), and a bowl of boiled rice. Partly because of the large role that grasses have played in providing food for man, the semiarid lands are more often thought of as the place where agriculture began. Many root crops seem to stem from forest flora, but not all of them do. Tree-crops are chiefly of forest origin, but man probably planted

grains before he planted anything so slow-growing as a tree. Plants of aquatic origin, including rice, tend to have forest homelands, but grains of the millet-wheat group seem to have been native to uplands tending toward aridity. Further, their cultivation appears to have been more ancient than rice. It is therefore most probable that the cereals and civilization developed in favorable spots in a semi-arid environment and that the development of rice was stimulated by the successful exploitation of wheat. These assumptions are at least consistent with the locations of the earliest known civilized towns of any size. Civilizations are not conceivable without relatively dense populations, which in turn depend upon agriculture.

The Archaeology of Agriculture

The archaeology of plant foods, wild and domesticated, is only beginning to unfold, but the world is awakening to its importance and there is promise of new knowledge, like the twilight before a glorious dawn. Within another decade or two those who survive us will write a thrilling account of this new chapter in the science of man. Even now scraps of information are worth citing. We recall one of the latest contributions to the knowledge of plant foods of early man. Most of you have heard of that famous cave in China in which were found the remains of Peking Man. Embedded in the debris of that cave were masses of cracked shells of seeds which botanists have identified as hackberry (genus *Celtis*). A modern form, *Celtis occidentalis* var. *crassifolia*, still grows in western United States, especially in semiarid districts. Similar hackberry seeds are found in deposits of the Pleistocene or Ice Age in South Dakota and in north China. The mere presence of the cracked seed shells in the cave does not prove that they were eaten by man. Rodents could have carried them into the cave. However, Ralph W. Chaney of the University of California sought to solve this problem in a scientific way. He offered modern hackberry seeds to rodents and monkeys of several different species. Most of the rodents ignored them, but the few that ate them merely gnawed small holes into the shells to extract the kernels, whereas the shells in Peking Man's cave were crushed to fragments. The monkeys chewed the seeds and spat out the shell fragments, which were similar to those in the cave, but there is no archaeological evidence that monkeys lived

Photograph courtesy of C.M.Goethe, in Sierran Cabin. . . from Skyscraper



THE MODERN cultivated sunflower and the wild sunflower compared: an illustration of the improvement that can be accomplished in a plant by primitive farmers. Cultivated seed heads as large as any now grown have been found in pre-Columbian rock shelters in Arkansas and Missouri. The Indians of eastern United States were observed growing sunflowers by the first colonists. They ate the seeds parched and ground into flour and extracted an oil from them

in the vicinity of the cave when Peking Man was there. Since even modern Indians in western United States eat hackberry seeds, Professor Chaney gathered information from them. He found that their method was to crush the seeds between stones to secure the kernels and that the resemblance of these fragments to those from the cave approached identity. We do not know whether Peking Man chewed the seeds or crushed them between stones, but since he used simple stone tools, it seems fair to assume that he gathered hackberry seeds and carried them home to crack at his leisure.

Diggings by archaeologists almost everywhere have brought to light the charred remains of grasses and seeds, and botanists have usually been able to identify them. In the previous discussions on wheat and maize we have mentioned such findings. In the submerged remains of Swiss lake dwellings were found charred and natural remains of many cultivated plants, including wheat, barley, rye, oats, millet, celtic peas, and carrots. By such finds it has been possible to distinguish between the horizons of agricultural and nonagricultural peoples.

In the New World we now find special published articles on the pre-history of cotton, beans, peanuts, sunflower seeds, gourds and squashes, tobacco, maize, etc., each a fascinating chapter in the unwritten history of the world. One conclusion to be drawn from such data for the United States is that other kinds of agriculture were practiced in Kentucky, Tennessee, Missouri, and Arkansas long before maize was introduced into that region. In fact, the last crops to appear were maize and tobacco. Long before they were grown, sunflowers, squashes, gourds, and seed plants were a part of the agricultural economy of the tribes. A recent publication by George F. Carter * tells how the new data resulting from preserved seeds and fragments of the *Cucurbita* (gourds, squash, pumpkin, etc.) suggest that their cultivation in southeastern United States long preceded maize in the same area and that they found their way in pre-maize times into New Mexico and Arizona. In general, this new information fully justifies the belief that agriculture in the New World was developed independently and without influence from the Old.

* *Plant Geography and Culture History in the American Southwest,* Viking Press, 1945.

The Domestication of Animals

In the course of the foregoing review of man's achievements with the cereal foods we have often found it impossible to avoid some comment upon the closely integrated practice of domesticating animals, and it seems necessary that a brief look at the history of some obviously important farm animals should be appended.

When you begin to think about the domestication of animals you are moved to make certain assumptions. You take for granted that there was a time when no one anywhere thought of taming an animal; then you may try to guess what animal was the first to be tamed and compose an imaginary set of plausible incidents leading to the acquisition of a fireside pet.

You have a right to speculate in this way and may expect that most of your guesses have been made time and again by hundreds of other people. If you experiment by asking friends their guesses as to the first animal domesticated, you will find that many of them will choose the dog. They will be prepared to defend the proposition by such statements as: "Most savage tribes have dogs," "It seems most natural that man and dog should take to each other," etc.

In modern civilized life the term animal husbandry is used to designate the rearing of animals of economic importance. This, of course, includes those that produce meat, milk, hides, wool, and hair, or furnish power for traction and transportation, such as, cattle, horses, asses, hogs, camels, sheep, goats, reindeer, poultry, etc. While it is correct to say that the first domestications of such ani-



After Breuil & Obermaier

CAVE PAINTING OF A WILD BOAR, from the Cave of Altamira, Spain

ORIGINAL HOMES OF OUR DOMESTIC ANIMALS. It is conceivable that the pig, cattle, the ass, and the dog were domesticated independently in two or more areas. Once man domesticated a species, the idea would spread from tribe to tribe, suggesting experiments with all wild animals. It is probable that by trial and error, man selected the most tractable and genetically favorable species of mammals and birds for permanent exploitation. Food was not always the primary consideration: the chicken was and still is used in divination, the turkey and pea fowl were bred for their feathers, the camel, elephant, and horse for transportation, etc.



mals were prehistoric and therefore shrouded in mystery, we should recognize that paleontology and archaeology do furnish some pertinent data for a few sound conclusions as to when and where the rearing of the most important animals was first achieved. Since we assume there was a time when the ancestors of modern man were in most respects wild men living among the wild ancestors of our domestic animals, it may help us to look backward to see what wild beasts were their contemporaries.

Paleontologists and archaeologists seem to agree that the earliest human bones known are those of *Homo mojakertensis*, found in Southeast Asia in fossil beds of Early Pleistocene time, the geologic period that began approximately a million years ago. However, the human bones to which we have referred are from fossil beds in late Early Pleistocene time. Among the wild animal bones in these same beds were earlier representatives of the animals we know today as elephants, horses, cattle, deer (two kinds), and camels. Pigs appear with man in middle Pleistocene time; sheep, wolves, foxes, etc., appear with other human bones in the late Pleistocene. Thus it is clear that species of the great families from which the world's livestock was derived by domestication were characteristic of Pleistocene time. And the first men we know anything about (six or seven extinct species of man) were a part of the wildlife of that era and preyed upon these wild animals, at least as soon as they learned to use fire and make crude tools. There is every reason to assume that increasing human population spurred early man to hunt in teams and to stalk the larger animals, driving them into bogs, over cliffs, and into pits dug for the purpose. Fire was obviously one of the most powerful weapons in this cooperative trapping and killing of game. Positive evidence of fire appears with man of the Middle Pleistocene in Eastern Asia and persists through Late Pleistocene to the present. Its use may not be as old as stone tools and speech but is relatively very ancient.

Another assumption upon which there is general agreement is that the invention of agriculture and animal husbandry came at a relatively late date and must be credited to *Homo sapiens*, the human species to which we belong. Archaeologists have observed no signs suggesting the domestication of animals or plants by any earlier but now extinct species.

If the reader is interested in possible biological evolutionary changes in man's structure and function, he should note this coincidental advent of a new human species and such a revolutionary way of living as the domestication of plants and animals. There is a puzzle here. The use of speech, fire, clothing, dancing, and many other fundamental inventions are credited to extinct species of man. Was it necessary, then, that the world wait for a new species to evolve before another series of epoch-making inventions were achieved, few, if any, of which appear more difficult than those preceding? If there are such things as true paradoxes, this may be one of them.

Order of Domestication

The usual assumption is that the dog was the first to be domesticated. One of the supporting arguments is the almost world-wide distribution of the dog. There is a widely accepted theory that the larger the geographical distribution the greater the age, though no critically minded person regards such evidence as infallible. However, the dog is the only domestic animal common both to the Old and the New World in ancient times. Even so, the dog appears late in the archaeological record, about on a level with agriculture in the Old World. In the New World his remains appear relatively late; they are conspicuously lacking in the sites associated with extinct animals, as at Folsom, Clovis, and the Strait of Magellan.

Turning back to the Old World, the pig seems to rank next in extent of distribution, reaching the far western and eastern margins



After Capitan and Breuil

A CAVE ARTIST'S IMPRESSION of a herd of wild reindeer, engraved upon an eagle's bone, Magdalenian time, France

of the land mass, and extending into the Pacific Island area. A number of species with local distributions seem to have been domesticated, whereas with most domesticated animals the tendency was to exploit a single species, which was then spread abroad by man himself, suggesting a single source of origin. In fact, whenever more than one species of ancestor is suspected, the scientist feels impelled to assume independent centers of domestication.

Somewhat smaller distributions belong to cattle. And we have some archaeological evidence suggesting still later dates for the domestication of most of the other domestic animals, such as reindeer, horse, ass, sheep, goat, camel, elephant, poultry, etc. In this way the following time sequences have been proposed: (1) among the first, the dog and the pig, (2) next in order, cattle and reindeer, (3) sheep before goats, (4) the ass before the horse, and (5) the horse before the camel and the elephant.



ENGRAVING OF A WILD REINDEER: European cave art. This is the most famous sketch of its kind

After Keith Henderson, in Primitive Man, *E.P. Dutton & Co.*

In much the same way the ranges of the wild species suggest the places of first domestication, as shown in the map on page 47.

For the dog, two separate derivations have been proposed,—jackal and wolf. For horned cattle, three localities are offered, and possibly as many subspecies,—the steppes, the valley of the Euphrates, and forested parklands in Europe. In the case of the pig, several localities ranging from Spain to Burma are suggested. Yet these are still little more than hypotheses. In the New World the dog seems to have been introduced from Asia.

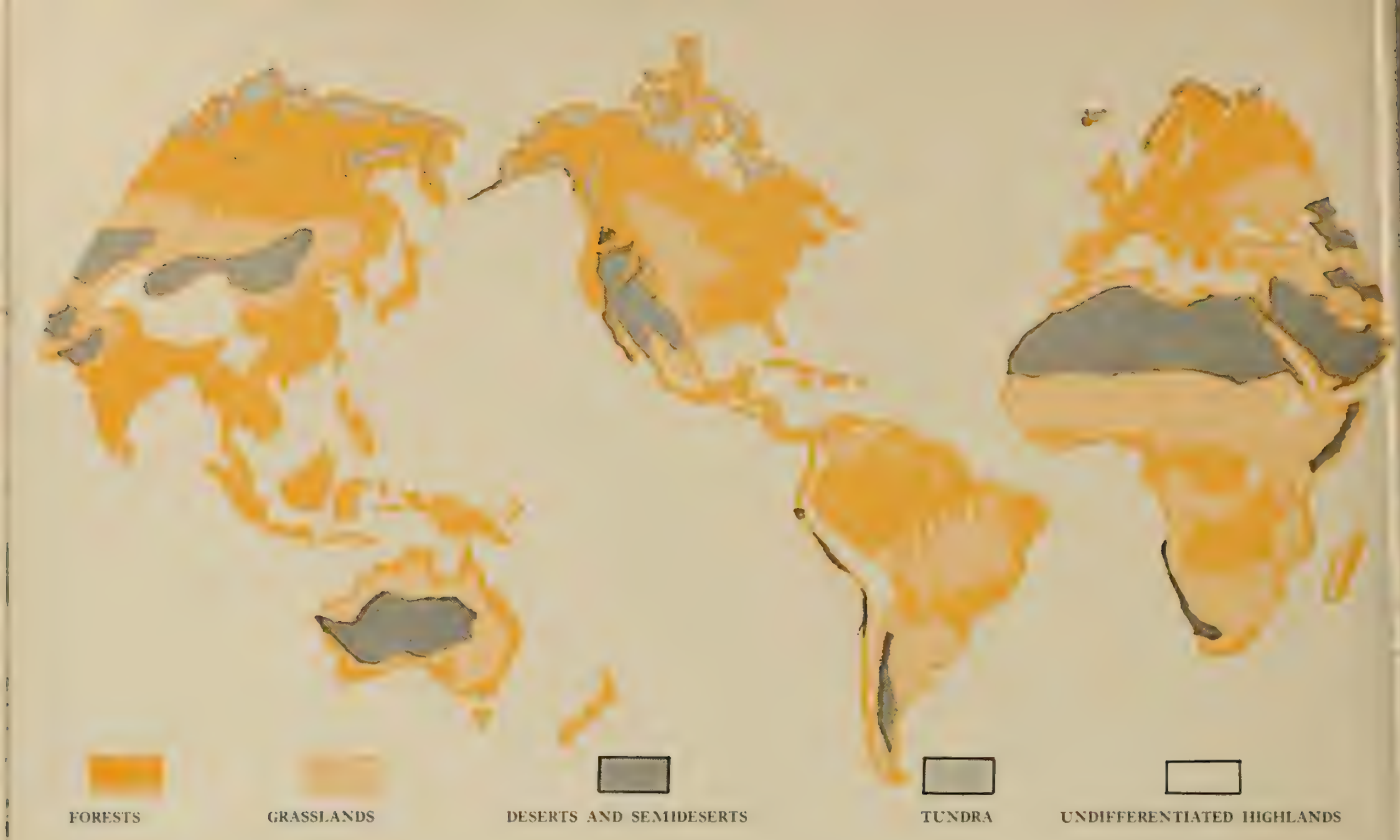


CAVE MAN AND THE WILD BOAR. (*From Obermaier's* Fossil Man in Spain)



A CAVE ARTIST TRIES his hand in sketching herds of galloping wild horses. A slab of stone from Cave of Chaffaud, France

After Cartailhac



GRAZING AREAS OF THE WORLD. Nomadic peoples frequented the margins between deserts and grasslands, where with expert handling, cattle, horses, sheep, and goats would fare well. Domestication only required substitution of herding for any habitual seasonal migration behavior the wild stock may have acquired. The pig did not thrive well in either desert or grasslands: forests, moist and even swampy, were his natural habitat. His range, in the Pleistocene, was from India to extreme western Europe, including the Fayum in North Africa

Habitual Associations between Man and Wild Animals

When people argue that it was natural for dogs and men to tolerate each other, they have in mind the differences that are obvious in the inborn behavior of the various other species of animals. For example, one reason for favoring the pig as one of the first wild animals to be tolerated in a camp or village is that in many parts of the primitive Old World, especially in New Guinea, the female pig with her litter moves freely about the village to feed upon offal and scraps of food discarded by the various households. The mother pig learns to look upon individual families as the source of regular "hand outs," and in turn her piglets are fondled by the children of the household and not infrequently allowed to feed from the breasts of the women. On the other hand, the adult boar is not tolerated in the village but banished to the surrounding bush, where he is hunted like other wild game. However, since the females



DRIVING DOMESTICATED PIGS to market: a scene among the Bontoc Igorots in the Philippine Islands. The distribution of the several wild species of swine was apparently almost world-wide, but domestication seems to have originated in Egypt and far-eastern Asia



THE REINDEER is not a strong animal but can carry a medium-size person or a light pack load. Lamoot Woman and daughter, Siberia

are not kept in pens but run about freely, the wild boars have no difficulty in meeting them at night or in the edge of the bush by day. In the village the pigs not only destroy accumulating garbage and filth but prey upon crawling and creeping creatures whose presence would be more than a mere nuisance. The natives not only recognize these services but, since the pig bears two litters a year, look upon the animal as a steady food supply. In the forested regions of western Europe hogs were herded while feeding on nuts and roots and in time were propagated for food and hides. Read the opening scene in Scott's *Ivanhoe* for an understanding of the economic importance of pig culture in Middle Age Europe. Even then boars seem to have run wild and been pursued by hunters, the head of the wild boar being regarded as the prize of the epicure.

Reverting to the dog, it is usually assumed that its wild ancestors, attracted by discarded food and the warmth of the campfire, gradually wormed their way into human society and rewarded those who tolerated them by detecting the approach of enemies and volunteering assistance in the hunt. Thus the association between dog and man could grow up naturally, the only surprise being that there is no trustworthy evidence for such mutual tolerance before the appearance of agriculture, about 10,000 years ago.

Wild cattle and reindeer were grazing animals, inclined to form relatively large herds and to seek tundra, grasslands, or park lands (open spaces in forested areas). Both are adapted to cool climates or seasonable habitats, in which they learn to migrate back and forth from north to south. The reindeer range farther north, even to the margins of glaciated areas, while cattle prefer the milder climates of the temperate zones where wet and dry seasons alternate. Reindeer roamed over middle Europe in glacial times, and since

CAMP OF NOMADIC KORYAKS, Siberia, with their domesticated herd of reindeer. The wall-tent in the center belongs to an American Museum of Natural History Expedition. The large tents are covered with reindeer skins, which with their poles and the baggage of their owners are transported by sleds drawn by trained reindeer





A.M.N.H. photo

THE WILD ASS OF THE GOBI DESERT. The ancestors of the long-eared, heavy-muzzled, droll-visaged donkey ran wild in North Africa, a different species from the more horselike creature of the Gobi. Certain low-relief sculpture of the Sumerians show asses of the Gobi type harnessed to chariots, apparently valued for their speed, whereas the Egyptian artists depict the heavily-laden donkey, plodding beside his foot-going master

they still survive in wild herds in Arctic and sub-Arctic latitudes, we may assume that they shifted their range with the glacial cycles, northward in interglacial periods and southward in periods of advancing glaciers. No doubt the several species of man were troubled by these same cycles of cold weather. Four periods of alternating glaciation are accepted as having occurred during Pleistocene time. Post-Pleistocene time, in which we now find ourselves, may well be the fourth interglacial period, to be followed in the distant future by a fifth glaciation. Consistently enough, the earliest known man (*Homo modjokertensis*) appears in Java during the first interglacial period when the climate there was probably tropical, as at present. Middle Pleistocene time seems to begin with the second glaciation, and this is when man in China (*Homo sinanthropus*) began to use fire, probably with good reason.

Whether reindeer were the first large grazing animals to be domesticated is not very important, and there is some reason to suppose that the date was much later than that for cattle. It is probable that cattle were among the first, but sheep may have preceded them, since at the famous archaeological site of Anau, Turkestan, bones of sheep were found beneath those of cattle. Some weight should be given to priority for sheep on the grounds that they are probably easier to control than either cattle or reindeer. But sheep were probably domesticated in one locality and cattle in another, so that it is difficult to prove which should be given priority in world chronology. Goats, also, may have preceded cattle, but the archaeological record seems to reveal no goat bones earlier than those of sheep or cattle.

Cattle, reindeer, and goats were milked, so we have no basis for deciding whether flesh or milk was the primary consideration. Asses and horses were milked too, but since it is assumed they were domesticated later than cattle, the use of their milk could have been suggested by cattle herders. In any case the first domesticated animals to be milked would suggest experiments with other domesticated species.

The chief interest in reindeer is that both wild and tame reindeer survive and that not



WILD CATTLE from Grotte de la Mairie, France. Horned cattle were widely distributed throughout Asia and Europe before the Age of Man. Good pictures of them appear in *Cave Art* after Capitan and Breuil



Drawing of a wild horse from the walls of Font-de Gaume, France, considered one of the finest examples of cave art

After Keith Henderson, in Prehistoric Man, *E. P. Dutton & Co.*

so long ago some Siberian tribes treated wild reindeer as game, killing them in the chase. At the same time, other tribes, recognizing that even wild reindeer moved in herds, shifted their camps with the migrating deer, taking care not to stampede the herd. Still others exercised some control by gently driving the herd to new pastures, protecting it somewhat against wolves and even against other hunters, thus naively conceiving ownership of a particular herd. At the other extreme is the complete control of the herd and the use of some individual animals for transportation, by saddle and sled, for milking, etc. It is not difficult to see here all the logically conceivable steps in the gradual domestication of the reindeer. The story for the domestication of cattle, horses, and other animals could have followed the same pattern.

Man's ability to provide protection for animals and supply food in times of scarcity puts the herded animals in his power. For example, the winter-feeding of elk in our National Parks tends to hold them to the feeding ground; the herd will stay around the spot and starve rather than migrate to fresh pastures. When mounted herders drive them to new grounds where feed is abundant, the homing instinct of these erstwhile wild elk brings them back to the feeding place, where they will die of hunger if not fed, failing to remember the places where pasturage was plentiful. It would seem that in providing winter food for a single season wild elk were essentially domesticated and rendered incapable of survival. If they had been herded on the new range for the season and then returned to their former feeding ground and this process continued year after year, we should regard them as domesticated. After all, there is nothing very mysterious

The Przewalsky Horse of Asia, assumed to be a descendant of the wild horse of Stone Age France, depicted above





After Leon Legrain, The Univ. of Penna. Museum Journal, 1924

AN ANCIENT CARTOON for a "bedtime story," showing foxes milking a goat, suggesting that people of the time milked goats from behind. We note further that the concept of the fox as a trickster is ancient, perhaps handed down from the Old Stone Age. The original drawing was found at Ur

here: we mention it to clarify our understanding of what may have been a natural process.

Tribes specializing in the control of flocks and herds but making no attempt at agriculture, are usually characterized as nomads or pastoral peoples. Some years ago there was a favorite theory that, in the evolution of society, hunters passed first from hunting to herding and later took up farming. This can be made plausible, but it is now realized that the environment determined where herding and agriculture could best be developed and that the first great civilizations were brought about by a combination of stock raising and agriculture. We have previously suggested that the most favorable locations for such an integration were the narrow valleys of rivers coursing through deserts, as the Nile, Euphrates, and Indus, where, during the rainy season, herds could be pastured upon the adjoining desert lands and brought back to the marshes and deltas for winter feeding.

As in the case of plants, man soon learned that selective breeding could rapidly change the body build and the behavior of his live stock, if mating were rigidly controlled. Sheep wool is so different from that of surviving wild sheep that its origin is considered to be due to man's care in breeding. In western Canada the Indians even bred a strain of dog with white wooly hair, excellent for spinning. They also spun the hair of the local wild goat but without domesticating him. The hair of surviving wild sheep in North America is too smooth to be practical. In Peru, the hair of llama, alpaca, and vicuña was used to spin yarns, usually for the warp in cotton fabrics.

In conclusion, it is by no means clear whether the larger share of credit for the domestication of animals can be justly claimed by man. The behavior patterns of the animals to be domesticated may have been the first cause, and the long delay on the part of man may have been due to his own predatory habits, which automatically classed him with the larger carnivorous animals. That man made little effort to domesticate tigers and lions is clearly logical; and in a region where

EGYPTIANS milked from the right side. Cow's legs were tied to protect the milker. 28th century B. C.

After V. Gorden Childe, Man Makes Himself





After Breasted, The History of Egypt

CATTLE CROSSING A CANAL. Two breeds of cattle appear in this scene, horned and hornless. Note the calf carried before its mother to lead the herd. The Egyptians took pride in their cattle, often showing herds on the march and in stables. The animals were used for draft, milk, and beef. The domestication of cattle may have preceded agriculture. In our alphabet, "A" is of ancient origin, derived from the picture of an ox head, inverted. Date of drawing about 3000 B. C.

people lived by hunting it is far from obvious that herds of relatively defenseless animals should seek food and protection around the camp.

Yet there are suggestions that when hunters came to be in part farmers and their food crops lured grazing and root-eating animals to the villages, the villagers would be prompted to adopt one of two expedients in defense of their own food supply—driving the herd away or leading it to pastures farther afield and holding them there. Thus automatically and without thought on the part of anyone, a habitual relationship between the herd and the village would evolve and perpetuate itself. Later, some speculative sage would make an original contribution to social belief by remarking that the herd was now community property. Note that the relationship between the herd and the village first came to be a reality; only later was *thought* applied to it, giving expression to the relationship in words and finally causing it to be taken for granted.

The part that the much vaunted "human intelligence" played in the achievement seems to fade into obscurity. The herders may have been as blind to the initial steps in domestication as were the herded. Why, then, should we be astonished when told that some ant colonies keep herds of "milk-giving insects?" Probably because we consider man very intelligent but look upon the ants as devoid of that quality.

After James Henry Breasted, The Conquest of Civilization



THE DONKEY was the primary beast of burden and everywhere preceded the horse. Women and children rode it, men walked. Egyptian drawing, Pyramid Age

Inventions During the Long Pre-Civilization Period

A final perspective may be gained by attempting a resume of the evidence that the beginning of plant and animal domestication was the primary stimulus to his culture evolution.

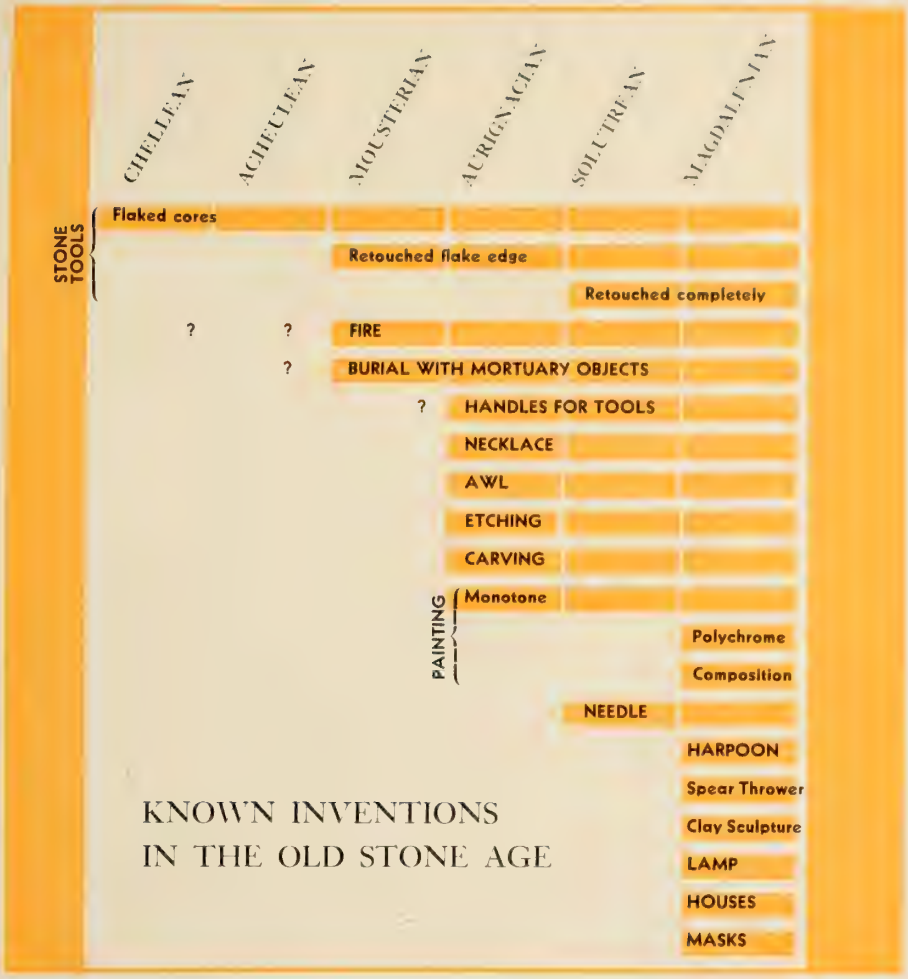
We should not overlook the important fact that man was a speaking, thinking inventor for several hundred thousand years before the relatively recent civilization boom. Fire was probably his first great invention. Inventing a handle for the stone axe was another great step. Twisting string was another. Then the inventions of art—line drawing, sculpture, clay modeling, color painting, perspective, and composition—all appear before civilization. The invention of needles in Solutrean time tells of another great step. Again the burial of the dead with mortuary offerings proves that early man was by no means slow in constructing a religious philosophy. The chart we give for outstanding inventions during the Stone Age speaks for itself. It reveals part of the preparation man had made for the rapid, astonishing speed of achievement in civilization when the release came.

As a nomadic hunter man could never grow numerically strong. Even with the best possible social organization, camps of hunters must be small and scattered. Critical studies of living conditions among surviving savages gives no ground for believing that the population of the world under a purely hunting and gathering economy could have been large. The approximate land area of the world is 50,000,000 square miles; the estimated land needed per capita to support a hunting population is seven to ten square miles. Then in round numbers the expected primitive population of the world in 7000 B. C. would not exceed 7,000,000—about the population of New York City.

Yet we know that cities of moderate size accompanied the rise of civilization and that achievements of civilization would have been impossible without local concentration of thousands of adult human beings.

A British Columbia Indian weaving a blanket of yarn spun from the wool of the white dog shown at her right. These dogs, bred and sheared for their wool, became extinct soon after white contact





A Possible Explanation

The reader may still be perplexed as to why it was just here in these deltas and narrow river valleys in the midst of deserts that civilization happened. The answer may be that these were the most favorable places. As local environments they were very much alike. What we do know is that these rivers flooded regularly once a year, that the people found it easy to grow cereals there, that cattle, donkeys, swine, sheep, and goats were in the country. We expect these animals would crowd into the fine feeding grounds of the deltas at least at the times of the year when the pasture on the arid uplands was thinnest. When man was forced to seek refuge in the same place, he found the animals in possession. Wild animals, wild plants, wild men, all predatorily inclined, crowded into the same narrow river valleys, and, not unlike flood victims on a raft, were forced by necessity to adopt a more economical use of space. Man's type of behavior was best able to cope with this new situation. He may never have faced the like of it before, but if so, he had failed. As a hunter with several hundred thousand years of experience with animals, he knew how to fight off the lions and other carnivores to protect the peacefully inclined ruminants. Nature herself gave yearly demonstrations of planting crops of grasses and of irrigating the marginal dry lands. So man could begin to co-operate with the herbivorous animals and to exploit plants. Because of increasing food supply, his own numbers increased geometrically, cities arose, herds multiplied, and cereals improved.

The many pictures of kings killing lions, wild cattle, etc., may not be just sport but symbolic of man's war against the wild animals from without that menaced the increase of his tame herds and threatened his growing crops. Also there were envious



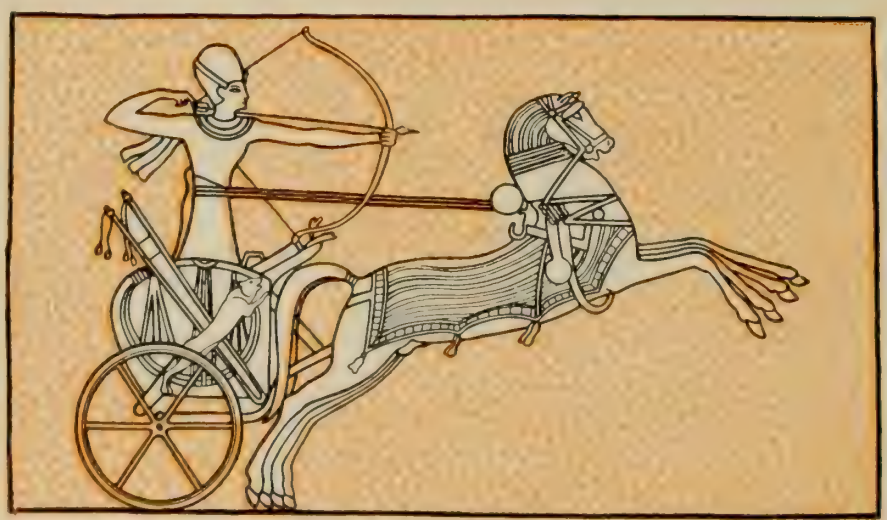
THE AZTEC AND INCA CITY STATES OF 1492

nomadic hunters on the outskirts, learning to be farmers and herders by imitation, ready to raid and dispossess the civilized of their rich lands, herds, and cities. New blood and abilities were ready to displace the old to carry on to greater achievements.

Most of this is speculation, but whatever the causes, it did happen. Once man sensed that he could by self-discipline produce more and more food and comfort, a few centuries would suffice to rear mighty cities and great civilizations. Significant changes in the ways of living would follow within a single generation.

Yet at the outset the ages-old nomadic hunters might need something more than the shock of a strange environment to break old habits; at least nature was kind enough to offer yearly demonstrations in sowing and irrigating. We shall never know, but the facts we have hastily reviewed offer some hints as to how it may have been that civilization arose around these river deltas as revolutions in living. The explanation may lie in the commonplace circumstance that for part of the year man could graze his herds upon the dry lands marginal to the rivers, while producing enough grain and hay along the borders of the river to stable-feed the animals when pastures failed seasonally. What we call civilization may be little more than wise integration of farming and animal husbandry.

THE Spanish explorers following closely on the heels of Columbus found two large political units in the Americas, the Aztec regime in Mexico and the Inca in Peru. The relative extents of these so-called empires are shown on the map. Many books have been written seeking to prove that these were not empires like those of the Spain, France, and England of 1492, which is true; Aztec- and Inca-land were different because they were not modern but reminiscent of Egypt, Ur, and Indus of early days. They were city-states and had evolved along lines generally parallel to the Old World city-states just mentioned. The two outstanding seats of power were the Aztec City of Mexico and the Inca City of Cuzco. Between and surrounding these two



EGYPTIAN WAR CHARIOT. Well trained horses were guided chiefly by words, but usually by a separate driver. The chariot spread to Europe and was used effectively by the ancient Britons in wars against the Romans

After James Henry Breasted, Ancient Times



THE EGYPTIAN King Ramses III, hunting wild oxen in the delta marshes of the Nile. In the Euphrates country, hunters speared lions from chariots and sometimes from horseback

After James Henry Breasted, A History of Egypt

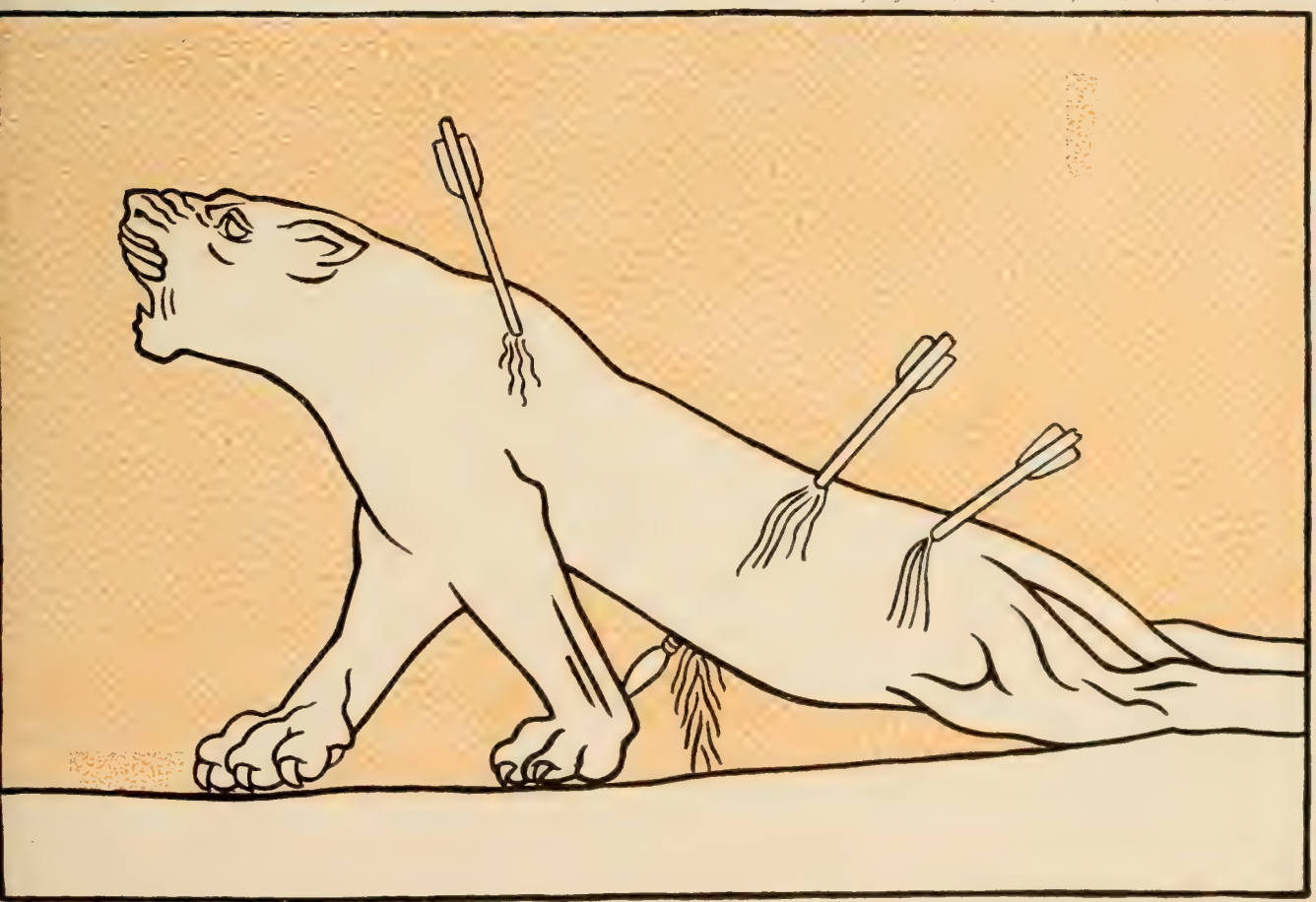
dominant nations were smaller city-states.

The Old World city-state pattern of empire began with Ur and ended with Rome, after which the Dark Ages of the barbarians prevailed, to emerge eventually through feudalism into the Christian type of empire of which the Spain of 1492 was a good example. The Aztecs and Incas, on the other hand, were yet evolving a stone and bronze age type of city-state civilization. This is why the favorite way to characterize these American aboriginals in 1492 is to say that they were engaged in an evolution of civilization, in a way parallel to what had happened in the Old World, but about 2000 years behind schedule.

We gained an insight into Old World civilization by noting that its distinctive characteristics were cereals and animal husbandry. Everywhere and even now among the heirs of these Old World civilizations wheat is the chief cereal. We shall find it equally important to recognize that the basis of aboriginal New World civilizations was

ONE OF THE FINEST sculptures in low relief depicts a wounded lion struck by arrows and paralyzed by a punctured spine. Ancient peoples hunted probably not just for sport but to protect their herds

After James Henry Breasted, The Conquest of Civilization



Outstanding Traits in Old and New World Civilizations

Old World	New World
Cereals (wheat, barley, etc.)	Cereals (types of maize)
Domesticated animals (cattle, horses, asses, sheep, swine, dogs, poultry, bees, etc.)	Domestic animals (turkey, guinea pig, llama, dog, bees, etc.)
Plow (drawn by man, later by cattle)	Digging stick (foot plow and hoe)
Wheel (cart, hand mill, potter's wheel, etc.)	No wheel (human packing, metate, hand shaped pottery)
Cities, aqueducts, and irrigation systems	Cities, aqueducts, and irrigation systems
Temples and state religious systems	Temples and state religious systems
Metals (gold, silver, copper, and bronze)	Metals (gold, silver, copper, and bronze)
Special hand crafts (as in stone, wood, textiles, etc.)	Special hand crafts (as in stone, wood, textiles, etc.)
Writing (wax and clay tablets, paper, inscriptions on stone)	Writing (paper, the quipu, inscriptions on stone)
Slavery and regimentation of labor	Slavery and regimentation of labor
Tribute, or taxes, imposed upon subjected cities	Tribute, or taxes, imposed upon subjected cities
State ownership of resources and land	State ownership of resources and land
State highway systems	State highway systems
Freight by ox cart, rapid transit by horses	Freight by human carriers and llamas, relay human runners, suspension bridges



THE OLD-WORLD WAY of grinding grain is the hand mill. It goes back to Ur, Egypt, and ancient times generally, and is still seen in Oriental and Mediterranean countries. The advantage of the revolving principle is that power can be applied. First, hand power was used, then draft animals, water, wind, steam, etc.

the group of cereals designated as maize (corn), accompanied by a weakly developed animal husbandry. Herein lies the chief contrast. We can now see the significance of our previous statement that Old World civilization is based upon a well integrated, nicely balanced economy of cereals and animal husbandry.

The Pattern of New World Civilizations

We found it useful to characterize Old World civilizations by enumerating fundamental traits defining a pattern in their then new way of living. It may be doubly illuminating to tabulate in parallel columns the traits most distinctive of the Old World civilizations as compared with those defining the character of New World civilizations, as in the accompanying table.

Close parallelism seems to dominate these two patterns, but certain differences are conspicuous. Thus in the New World there is neither the wheel nor its common applications in the cart, pottery wheel, and rotating hand mill. The metate, a flat slightly concave stone, is the New World device for crushing cereals for meal or flour. Secondly, neither cattle, horses, sheep, nor swine were known. Instead of the time-honored plow, the New World used the simple digging stick, with its more specialized form, the spade, or foot-plow. In other respects the two world patterns are remarkably similar. Yet what a gap these few exceptions leave in the profile of American aboriginal civilizations. To their Spanish conquerors the Aztec and Incas seemed contemptible—no cannon, no steel weapons, no metal armor, no horses, no oxen, no carts, man power only.



THE NEW-WORLD DEVICE for grinding grain: the metate. It is still in use in the United States, Mexico, Central and South America, and the West Indies. The grain is crushed between two stones by pressure. The principle of the revolving wheel was not recognized in the New World, hence the circular mill was unknown

Drawings by Paula Hutchison

Summary Comment

THE foregoing pages are presented as a brief digest of the available information about the important cereal and animal foods, the external universal pattern for mankind, "bread and meat." To save space and time the details are presented in outline form, hoping the reader may be able to sense their significance in perspective. Ever since man became conscious of the world as a whole he rarely fails to be moved by any realistic presentation of human experience in time and global space.

Another point of interest to us is that so far as is known the élite of the Aztec and Inca possessed some knowledge of the barbarian tribes on their respective frontiers but were wholly unconscious of an Old World and the achievements of its inhabitants. The possibility of such an entity as another hemisphere had not occurred to them. Small wonder is it that the appearance of Europeans with unheard-of weapons, ships, and horses, with a background of learning and insight incomparably more acute than they had ever experienced, rendered them incapable of any effective resistance.

Something more than a hundred thousand years of striving and thinking have gone into the making of this story of the homely routine of never ending daily chores which few families have ever been able to escape. We hope their direct recital may cast some glint of romance and inspiration over all. If the reader should find inspiration and insight herein and note the great gaps in existing knowledge of the subject, he can glimpse the grandeur of a similar synthesis some decades hence when anthropology, archaeology, paleobotany and paleontology have delved deeper into the past. Though scarcely two centuries old these sciences have revolutionized man's attitude toward life and his thinking. Not all his experiences for a hundred thousand years so radically changed his outlook.

Equally moving handbooks could be written on fiber plants (hemp, nettle, flax, cotton, etc.). Some recent archaeological studies have suggested that the cucurbits (gourds, calabashes, cucumbers, pumpkins, squashes, etc.) as a promising subject for research. The world wide history of the bean is another possibility. Finally the familiar potato which holds so secure a position in modern world diet furnishes material for a fascinating story.

Bibliography

Anderson, E. and Cutter, H. C. *Races of Zea Maize.* Annals of the Missouri Botanical Garden, Vol. 29. St. Louis, 1942.

Bailey, Liberty Hyde. *The Standard Cyclopedia of Horticulture.* Macmillan, New York, 1912.

Bishop, C. W. *Origin and Early Diffusion of the Traction Plow.* Smithsonian Report for 1937. Washington, D. C., 1938.

Brant, James. *The Chemistry of Bread Making.* New York, 1912.

Breasted, H. B. *Ancient Times.* Ginn & Co., New York, 1935.

Breasted, H. B. *A History of the Ancient Egyptians.* Scribner, New York, 1908.

Carrier, Lyman. *The Beginnings of Agriculture in America.* McGraw-Hill, New York, 1923.

Carter, G. F. *Plant Geography and Culture History in the American Southwest.* Viking Press, 1945.

Childe, V. Gordon. *Man Makes Himself.* Library of Science and Culture. Watts & Co., London, 1936.

Collins, G. N. *Pueblo Indian Maize.* (The Journal of Heredity, Vol. 5, pp. 225-268.) Washington, D. C., 1914.

Densmore, Frances. *Use of Plants by the Chippewa Indians.* (44th Annual Report, Bureau of American Ethnology.) Washington, D. C., 1928.

Forde, C. Daryll. *Habitat, Economy and Society.* A Geographical Introduction to Ethnology. Methuen & Co., London, 1934.

Furnas, Clifford C. and S. V. *The Story of Man's Food.* Reynal, New York, 1937.

Jacob, H. E. *Six Thousand Years of Bread.* Doubleday, Doran, New York, 1944.

Jenks, A. E. *The Wild Rice Gatherers of the Upper Lakes.* (19th Annual Report, Bureau of American Ethnology.) Washington, D. C., 1900.

Kroeber, A. L. *Peoples of the Philippines.* American Museum of Natural History, Handbook No. 8. New York, 1943.

Mangelsdorf, P. C. and Reeves, R. G. *The Origin of Indian Corn and its Relatives.* (Texas Agricultural Experiment Station Bulletin No. 574.) 1939.

Will, George F. and Hyde, George E. *Corn Among the Indians of the Upper Missouri.* (Little Histories of North American Indians, 5.) Harvey, St. Louis, 1917.

Wissler, Clark. *The American Indian.* 3rd Ed. Oxford Univ. Press, New York, 1942.

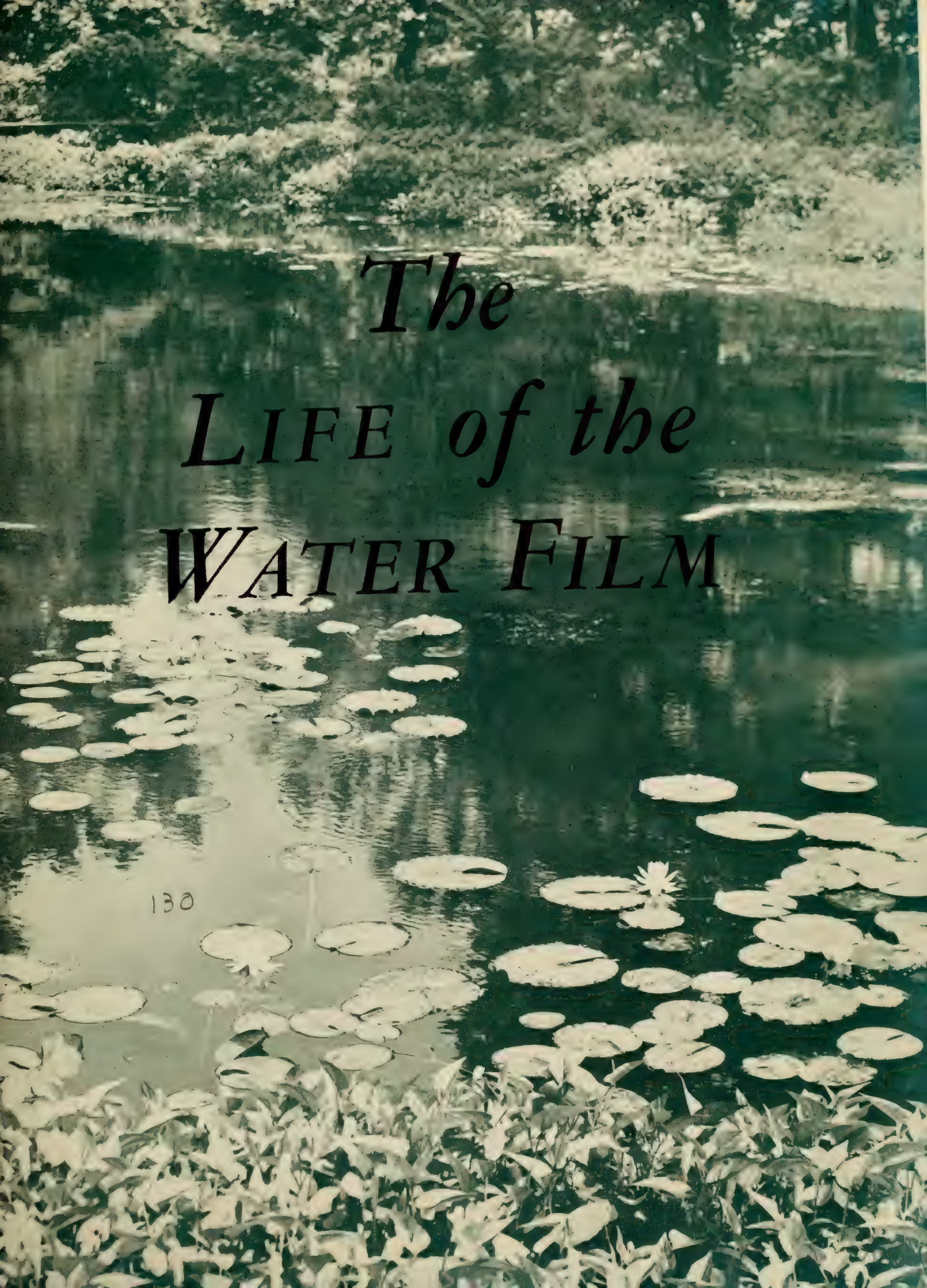
Wissler, Clark. *Man and Culture.* (Crowell's Social Science Series.) Crowell, New York, 1923.



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The
Life of the
Water Film
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➤ A WATER STRIDER rows dry-shod over the surface of the pond. The depressions in the film under each foot show strained irregularities

The LIFE of the WATER FILM

The lives of many small animals and plants depend upon the fact that water is not always wet

By LORUS J. MILNE *and* MARGERY J. MILNE

All photographs by the authors

ONE of the first facts learned by every child is that "water is wet." In more mature years this wetness is so taken for granted that any exceptions to the rule arouse great interest. Thus the sewing needle that can be lowered gently onto the surface of a tumblerful of water, there to float completely dry, is a startling discovery. Yet to a large number of different animals and plants, this problem of wetness and dryness is a matter of life and death. Many of them find the "dry" surface of water to be a place to live, albeit precariously. Suspended between the air above and the depths below, they inhabit the surface film of ponds, streams, lakes, and even oceans. Theirs is an almost two-dimensional realm, a special niche in nature for use of which certain requirements must be met.

When a substance attracts water molecules more strongly than water molecules attract each other, the water wets the surface. The liquid creeps along, invading every crevice, clinging tightly to each irregularity. But some materials, such as waxes and oils, attract water molecules so little that the water draws away, pulling back into itself and leaving the surfaces dry. Aquatic birds take advantage of this principle by regularly adding oil to their outer plumage, thereby keeping their feathers from becoming water-soaked. The many creatures that walk on water do so by means of well-waxed, hair-booted feet which the water cannot wet.

Best known of all the animals that walk dry-shod on ponds and streams are the water striders,—bugs with four long legs stretching out to the sides and a shorter pair held under the head. Their slender feet are covered with greasy hairs which the water fails to penetrate. Each foot presses the water surface and makes a dimple in it, but the water does not run around and let the foot fall through the surface film as it would if the waxy hairs were absent. Instead the insect's weight is supported partly by the buoyant force of the water displaced from the dimples and partly by the surface tension which tends to erase the depressions and bring all the water film to the same level. The strider uses chiefly its hind- and foremost legs to hold its body well above the smooth and slippery surface of the pond, while working the middle pair as oars to scull itself along. Mirrored in the water film below the bug is its image,—a reflected "double" seldom seen except by small creatures close to the water surface. Below the strider, on the bottom, are dark shadows cast not only by the insect, but also by the dimples in the surface film where its feet press downward. Sometimes, on sunny days, these shadows on a sandy bottom are more conspicuous than the insects themselves. They drift along and follow every movement of the rowing striders on the film above.

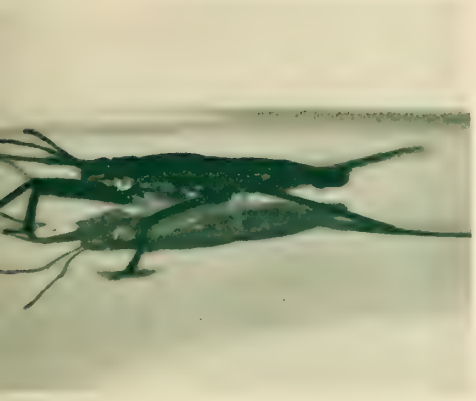
➤ A QUIET POND provides the naturalist with an excellent opportunity to study the life of the water film



A considerable *length* of surface must be called upon to support an insect as heavy as a full-grown water strider. If its hair-booted feet pressed on the film at only six small points, the bug would penetrate into the water and sink at once. But the strider's legs are spread so widely that its feet make elongated dimples or furrows in the water film. So secure is the insect on a quiet pond or stream that it can shift its weight freely among its feet. Most spectacular are the demonstrations of this when a strider cleans itself. Drawing its rowing legs far back, it stands with its head almost in the water, while its hind legs are raised well above the surface and rubbed one against the other much as the housefly does. Then the insect rests on forefeet and one hind foot, with the rowing leg on that side as an outrigger, while the middle and rear feet of the opposite side are raised into the air and rubbed free of clinging particles by a similar fiddling movement. To accomplish this contortion, the bug practically lies down on its side. The water film stands the strain, but the shadows cast on the bottom shift and spread as the pressures on the fewer surface furrows are increased. Finally the strider stands on rowing feet and rear pontoons while its body and forelegs are raised high above the water. The insect washes itself much as a kitten does, transferring dust particles from feelers, beak, and body to the forefeet, then rubbing these together until they are satisfactorily clean. The bug seems to give great care to every detail, and if uninterrupted, such a complete toilet operation may take ten minutes.

The Quest for Food

Other animals that spread their weight on outstretched feet can rest with safety on the water film. Small gnats and midges flit from place to place on ponds, alighting with equal equanimity on film or foliage. Even large crane flies settle with surprising grace upon the water surface, and rise again with their long legs trailing behind. Each foot combines the advantages of waxed hair covering and slender length which can distribute the insect's weight along the surface film. Sometimes the water striders catch small flies that fail to take flight in time. Occasionally, too, a crane fly dies of unknown causes while resting on the water surface. Without muscle action to hold its body well above the water, the insect sags into the pond and sinks in or barely stays afloat. Water striders gather around it to salvage such nourishing juices as remain. It is but one of the many types of food the striders seek as they push their way along the transparent but rubbery surface film. Some of their sustenance floats up to them from below; each dead fish attracts a crowd of striders. But most of the food of these insects falls into the water from the air above. Ants tumble from leaves overhanging the water. Beetles close their wings and drop or blunder into ponds and streams where the water wets them and renders them helpless prey to the predaceous bugs. The striders investigate every particle, often making great leaps over the water to reach some newly fallen object. Small particles such as drowning ants are picked out of the surface film and held on a slender black beak while



▲ EACH STRIDER has a "double," mirrored by the surface of the water

◀ TWO STRIDERS approaching the cast skin of a *Dolomedes* spider. One strider carries an ant around on its slender beak while removing the nourishing juices. Only the under surfaces of the ant and the spider's "ghost" are wet

the life juices are drained away. Often a strider is seen carrying with it a gnat or other carcass as it glides along the water surface. Occasionally other striders chase the food-bearing relative across the pond, just as chickens pursue a hen fortunate enough to have found a large grub.

On ponds and streams the striders stay close to shore or hurry to reach it if a breeze springs up and the water's surface becomes ruffled. In rain and in winter, the striders leave the water and crawl out upon the bank. In spite of these precautions, the insects do get wet at times. Although they show great ability in navigating streams, and can spring ahead to make progress against the current, an occasional bug is swept through a riffle and fails to stay afloat. In such situations, striders may be found below the surface film, rowing to shore where they can crawl out again to dry and clean themselves.

Seagoing Striders

There is also a seagoing water strider,—a small gray form common in tropical and subtropical lagoons and mangrove swamps, where it congregates in large groups. These same water striders are found at great distances from land, riding the waves like the best sailors. No one knows what they do during a storm at sea or when it rains. They must get wet, and what is there to crawl out upon to dry? To add to the problem, these seagoing striders often crawl down into the water during calm weather, and row along to feed there, upside down, on the underside of the water film. Many of them live out their lives hundreds of miles from shore and raise their families at sea. The eggs are laid on seaweed at the surface of the ocean or on the infrequent feathers dropped by sea gulls.

Spiders and mites of several kinds frequent the water film in pursuit of the insects there. They have the same means of staying dry as do the striders, and they scamper about on ponds picking up food wherever they can find it. Most of the water spiders are tan with dark stripes. Many of the females lay their eggs in a creamy sphere of silk, and drag this precious ball after them wherever they go, even out upon the water film. One of these ball-making spiders is a giant called *Dolomedes*. A full-grown mother may measure two inches or more between the tips of outstretched legs; her egg sphere may be half an inch in diameter and contain hundreds of potential spiders. Even after they hatch, the spiderlets stay with their parent, and the adult is often seen with a fuzzy covering which can scurry off, like goslings from a mother goose. Such a family group is quite a prize for a hungry fish, and those spiders that hesitate while running on the water film may lose their lives. However, spiders seldom stop on the surface; they run from shore to plant or from leaf to lily pad, carrying their prey with them to a safe spot. But fish in ponds and streams follow walkers on the water to profit from their occasional unwariness. Sometimes a fish makes a mistake and seizes a spider's ghost,—the empty, castoff skin. Often these skins float downstream, casting on the bottom a shadow much like that of the spider itself. But the skin rests on the water like a dead crane fly, while the living spider walks well above the surface with only its eight feet furrowing the film and making sharp silhouettes on the sand below.

Most conspicuous of the water mites is a common one with a ball-like body of brilliant, velvety red. The full-grown mites reach a diameter of a quarter of an inch. They run so smoothly on their very short legs that they seem to glide over the surface film rather than move on distinct feet. The females leave solitary brown eggs on floating vegetation, to hatch into immature mites with six legs instead of the characteristic eight. These larval mites spend a few weeks as parasites on some insect. They lie in wait for water striders or diving beetles,—anything that comes their way. Sometimes they ride on damsel flies; more often they catch the striders. One strider may carry several of these clinging mites, each sucking nourishment yet seeming to do little harm to its host. Eventually they drop off, molt to gain another pair of legs and the spherical form of the adult body, and forage for themselves as their parents do. The mites not only run along the surface, but frequently climb down plant stems into the water and swim about. Their eight short legs give them an even motion by which they may be distinguished easily from all other aquatic animals.

Catapult Take-off

Very small insects with waxy feet can stand upon the water film without the additional precaution of spreading their legs widely. The smallest mites have this advantage. So do the several kinds of springtails and the many leaf hoppers which jump over the surface. These animals are so very light that even when they press down sharply on the water film to throw themselves into the air and escape some danger, they do not produce any sizable dimple in the surface. The leaf hoppers have leaping legs like a locust's or a katydid's, but the springtails have a much more ingenious way of catapulting them-



▲ THESE WHITE, TRANSLUCENT AQUATIC LARVAE of a fly can continue to breathe while the front end works through the bottom ooze of a shallow pond for food. Each has a cup-shaped cavity at the posterior end open to the air, exposing spiracles (black paired marks). Through these, gas is admitted to white tubes which extend through the body. The creatures are less than half an inch long

▼ THIS MOSQUITO WRIGGLER hangs from the surface film by a whorl of waxy hairs around the opening of its breathing tube



selves into the air. They are grotesque insects, with an extended tail. Some merely keep this tail curved under them, almost resting on the water film between their six short legs. To jump they simply straighten out, but do so suddenly. Others carry the tip of the underturned tail in a special catch, like the notched trigger of a mousetrap. The tail is strained against the catch just as is the mousetrap spring. When the insect is frightened (or sometimes seemingly just for fun) the catch is slipped, the tail whacks the water film, and the springtail is thrown high into the air, to land somewhere else. For a creature so minute, air has an excellent cushioning effect, so that the springtail settles without damage, usually on its feet.

Two types of springtails are common on fresh water and one on quiet bays of the ocean. The more abundant of the lake and pond forms is bluish black, about an eighth of an inch long. It congregates in such enormous numbers as to appear as a conspicuous blue-black band along the water's edge. The individuals walk about among their fellows, but at the slightest disturbance, the group flings itself into the air like tiny corn kernels popping on a hot griddle. They alight many inches away, no longer in association with each other. To all intents and purposes they have vanished. Like other springtails, these have a tubular extension from the underside near the catch for the springing organ. With this "ventral tube" they are able to hold themselves to the water surface. The tube can be wet by the water and forms a sort of anchor for the insect. The seagoing springtail and the seagoing strider are among the relatively few insects that are not bound to a land or fresh-water existence. The seagoing springtail is found all over the world along sandy and muddy coasts and on tidal pools in rocky shore lines. No one knows what happens to them during storms and showers at sea. Not all of them can come ashore for such occasions.

Beneath the Film

The underside of the water surface is also used by a surprising number of aquatic creatures. Every now and again a pond snail crawls up a plant stem as far as the water surface, there to roll over and glide out under the water film, its flat foot pulsing with slow waves of movement from aft to fore along its length. In this position, many of the snails apply to the water surface a part of the body between foot and shell, and there open up the single hole that leads into the lung, so they can breathe in a load of air to take below. In very shallow water, a flat sole similar to that of

the pond snail, but much smaller, shorter, and narrower, turns out to belong to a worm which is all sole, with almost no thickness. This flat-worm, a free-living scavenger related to the liver flukes and tapeworms, is commonly called a "planarian" and seemingly has crossed eyes spotted on its speckled back. It is a source of never-ending delight to all biology students, and a laboratory pet with a firm grip on life. The animal is so elementally constructed that pieces cut from a single planarian can reorganize to form a whole. Biologists have worried out the philosophies of "self" in terms of many-headed, several-tailed planarians, which creep along the sides and water surface in laboratory jars to mock their captors.

Hydra

Another animal capable of remarkable regeneration is *Hydra*, named two centuries ago by a man who, discovering that it could multiply heads if mutilated, thought of the Greek mythical monster of that name. *Hydra* looks like a discarded umbrella without any cloth covering,—merely a stalk with long arms from one end. The arms are tentacles with nettling cells for catching microscopic life, and between the arms is an opening into the animal's interior, through which the prey is thrust for digestion. The opposite end of the stalk is armed with a sticky disk, the stickiness of which is under the creature's control. Often *Hydra* reaches a few of its tentacles upward and attaches them to some plant stem, then lets go with the sticky disk, to somersault in slow motion and glue its body to a higher point. Repetition of this process or a gradual gliding of the sticky disk may bring the animal almost to the water's surface. There *Hydra* often hangs, foot stuck to the underside of the water film, body pendant, tentacles outstretched for an inch or two beyond, waiting for unwary water animals to bump into its battery of stinging cells. *Hydra's* weight upon the water surface forms a dimple there, but the depression is not like the furrow under the water strider's foot. It is more similar to that around the snail or flatworm, and *Hydra* can creep along the water as they do, although with no visible waves of movement. These submerged creatures produce a water-repelling material from the flat area applied to the surface film. The water draws away, clinging wetly

▼ POND SNAILS in a shallow puddle. The one with the black spotted shell is on the bottom of the puddle, while the other crawls under the surface film. This photograph, like others in the article, was taken with a Bausch and Lomb Tessar lens treated with Balcote to reduce the flare



only to the rim of *Hydra's* disk or of the soles of snail or worm.

Two types of minute crustaceans upon which *Hydra* feeds have odd relationships to the underside of the water film. One of these, *Scapholeberis,* by name, has special waxy bristles with which to puncture the water film from below and lay hold upon it. Since these bristles are on the underside of the crustacean, the creature rests back downward, supported by the film. For purposes of camouflage its body coloring is related obviously to its upside-down position, for instead of being dark-backed and light-bellied like fish and most other animals, *Scapholeberis* is the opposite. In this position, the crustacean rows itself about with its long antennae, browsing on algae that float upward from below, and upon pollen and other flotsam accumulated on the water surface from the air above. A gust of wind tows the surface water and *Scapholeberis* attached to it,—a "sort of submarine sailing" some have aptly called it.

The other type of crustacean is typified by *Bosmina,* a tiny creature which is often trapped by accidently breaking through the water film as it swims along below the surface. Unless a wave or similar disturbance knocks the helpless creature below the film again, it must wait in this position—partly in and partly out of the water—until it can molt its skin and slip out of the old covering into the lake below. The difficulties encountered when a small underwater animal is caught by the "dry" surface of water are similar to those experienced by animals of similar bulk and strength when they fall into the water from the air. Unless a branch is near by upon which they can crawl out, they usually drown or are picked up by water striders and other carnivorous creatures that make this two-dimensional world their home. Even water striders have difficulties; readers of Frank E. Lutz' fieldbook are cautioned to carry home their striders in a dry pail, not in water, lest they drown.

The many insects that live in ponds and streams must have atmospheric air to breathe, and remarkable provisions have been made for reaching through the surface film.

Back swimmers, mosquito wrigglers, diving beetles, and other water beetles come to the surface from time to time to thrust through the water film some tubular mechanism in order to replace the air stored beneath their wings or in their breathing tubes. Only by such frequent restocking can they carry on their precarious submarine existence. Some of the fly young, shaped like maggots and other peculiar things, have telescoping segments at their hinder ends, which they can extend to and through the surface film for gathering air continually while the creatures burrow busily to find food in the mire. Some of the water beetle larvae not only come up to get their air but also drag living or freshly killed prey to the surface and thrust it out into the air, where it can give less resistance to being swallowed and where gravity can be of more help.

Whirligig Beetle

One of the water beetles has a greasy back which repels all moisture like the feathers of a duck. This is the whirligig beetle, which passes much of its life at the surface of ponds and streams. Actually, it is a double animal—dry above and wet below, with paddle-like feet to propel it rapidly through the water. Even its eyes are divided into an upper portion for vision into the air and a lower part with which to watch the water's depths. These beetles are very vigorous swimmers, familiar to most people as they zig and zag along the water surface, commonly in groups, leaving behind them little V's of waves like tiny speedboats.

Egg-laying

The water film forms a definite barrier for insects that must lay their eggs in the water itself, and an almost endless variety of solutions to the problem can be observed. Perhaps the simplest is that of the water lily leaf beetle, which cuts a small, circular hole in the dry top of its lily pad, pushes its abdominal tip through the hole into the water below, and while standing high and dry on a familiar surface, lays two rows of eggs on the undersurface of the lily leaf in close concentric arcs. Many dragonflies, caddis flies, May flies, and others extrude a single egg or a group of eggs from the abdominal tip while soaring over the water. They fly down close and suddenly flick the abdomen through the surface film and liberate the egg. Pulling quickly out, they zoom away to repeat the process when the next egg is ready. The insect's momentum insures it against being caught in the surface film and dragged in to drown. Much more careful are the ordinary biting mosquitoes, which literally lay a raft of eggs. The raft floats upon the water film with only its lower surface wet. The eggs hatch through their lower ends and the young wrigglers emerge into the water directly, many to be eaten at once by hungry beetle larvae and fish. The malaria mosquito, in contrast, lays her eggs singly on the surface of the water.

Another little fly, the *Dixa* midge, stands on the surface like a water strider while she deposits an extruded wet mass of eggs suspended by a strand of gelatine. As the egg mass is let down into the water, the fly adds to the supporting filament a circular, transparent disk which repels water. The disk catches on the surface film and pulls down a dimple as the strand below lengthens out and the suspended eggs sink farther into the water. The fly leaves, but the eggs with their little float drift around as the water surface is blown or as currents move the water itself. The eggs may become stuck to some vegetation or break their mooring and sink to the bottom, there to hatch.

Some other insects, when ready to lay their eggs in the water, wrap their wings around their bodies like a cloak, enclosing a bubble of air, and then crawl down stones or stems through the surface film and into the depths below. Those that succeed in laying their eggs and escaping capture in the water may later crawl back out into the air, dry off, and fly away. Male and female damsel flies co-operate in this. The male uses a pair of claspers at

the end of his long abdomen to hold the female by her slender neck. After her eggs are fertilized and seem ready for laying, the pair alight at the water's edge and the female backs into the water down some stem. The male holds on to her and remains above the surface at least as far as his wings. When the eggs have been deposited, the female starts upward and the male pulls, fluttering his wings, so that between their combined efforts, the female is brought out of the water again, to dry off and fly away.

These many special abilities and difficulties related to the water film are based on the very high surface tension which is so characteristic of this commonest liquid. Each adaptation in form or behavior is a means of using or of circumventing the strong surface forces involved. None of these methods do anything to change the surface tension itself. Yet this is possible, and is the basis of a familiar parlor trick. If a chip of gum camphor is dropped into a dish of water, the chip spins around and sails in erratic courses, propelled by a mysterious force. Actually the camphor is dissolving faster along some parts of the water line than in others, and since camphor greatly reduces the surface tension of water, the surface forces are weakest where the gum is dissolving most rapidly. The chip moves because of the inequality of surface forces pulling it from all sides. The weakest forces are behind the moving chip and show where the camphor is dissolving fastest.

One of the rove beetles makes use of this trick. Like its relatives, *Stenus* is an active little beetle, running or flying around much of its time in search of carrion or prey small enough to overcome and eat. Sometimes *Stenus* falls into a puddle or a pond. It has no waxed hair to keep its feet dry and therefore sinks well into the surface film, its legs and underparts thoroughly wetted by the water. But *Stenus* merely expels from its anal glands a substance that makes the water wetter—reducing the surface tension at its posterior end. Undiminished surface forces in front of the beetle promptly draw it forward. As long as the insect continues to emit this magic substance, it sails along with no apparent effort. Often the beetle reaches some dry object upon which it can crawl to dry off and again take to flight. This rove beetle can keep up its speedboating for many minutes, but if it is deprived of the abdominal tip with the anal glands, the insect is quite helpless in the water.

The leaves of some of our pond plants are like the whirligig beetles, with a water-shedding top and a lower surface that rests in and is wet by the water. Lily pads are of this sort, anchored to their loglike roots by long slender ropy stems. Their two surfaces support two different types of clinging life, one wet, one dry, while in between the water lily gathers up the sunshine energy to make it grow. The duckweeds too, small flakes of green, are always at the water surface. The larger kinds rest on the surface with rootlets dangling into the pond below. One of these duckweeds is our smallest flowering plant, floating freely just below the water film among the lily pads. Contrast with this the largest water leaf of the Victoria lily, whose six-foot disk with turned up rim will float a human child of medium size, all safe and dry.

When spring comes to the lake or pond surrounded by pine clad hills, the water film takes on a golden yellow cast with squandered pollen grains. The wind makes patterns of the driven dust, while the whirligigs cruise through it and raise a wake like tiny boats, rocking all the water bugs and giving rise to quiet lappings on the near-by shore. Spent and useless to the trees around, this pollen dies and sinks below. Throughout the years it may build up a layered record of the past. From just such fossil pollen we know many of the plants which lived and passed away but left no other mark. Pollen, wind, and water film combined to make a fossil trail of bygone trees.



Man and Nature

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Central Park West at 79th Street, New York 24, N. Y.

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FROM THE NECK UP

BY HARRY L. SHAPIRO

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Science Guide No. 131

NEW YORK

THE AMERICAN MUSEUM OF NATURAL HISTORY

1947



A WOMAN'S red silk hat from Tibet, the product of a people generally regarded as backward in terms of modern civilization but possessing an elaborate religion and a rich esthetic culture

How man, primitive and civilized, exercises his fancy in decorating his body, particularly

FROM THE NECK UP

A preview of a special, temporary exhibit at the American Museum prepared by

KATHARINE BENEKER
Supervisor of Special Exhibition Department of Education

By HARRY L. SHAPIRO
Chairman, Department of Anthropology, American Museum of Natural History

All photographs by AMNH

THERE are living in the world today thousands of groups, tribes, populations, and nations. And among all this assemblage, it would be difficult to enumerate a dozen different groups completely content to leave their bodies as nature made them, unadorned, undecorated, and unmarked.

This passion for embellishment ignores climate, comfort, pain, or inconvenience. The dwellers in the tropics who have reduced clothing to a minimum or have discarded it altogether, scarify their flesh to produce keloid or scar tissue in patterns of bas-relief, pierce their noses to carry ornaments or other objects of virtu, elongate their necks with coils of brass, stretch their lips around huge discs, and in various other ways find means of decorating or mutilating their bodies. Inhabitants of cooler climates who find clothing a necessity also make an adornment of it, often obscuring its basic function under a mass of decorative and tortured detail.

While much of this artificial enhancement of the person is relatively of little or no inconvenience and in the case of clothing often of distinct value to the organism, men and women will endure for the sake of it incredible agony, torture, and discomfort. The comparatively mild distress of corset wearing pales before the pain of Chinese foot-binding, head deformation among the Aymara of South America, the tooth evulsion of some African tribes, and the subincisional surgery of Australian aborigines.

In fact, so universal is this urge to improve on nature that one is almost tempted to regard it as an instinct. Aside from such fundamental drives as those for food, love, security, and the expression of maternal solicitude, I can think of few forms of human behavior that are more common to mankind as a whole. Perhaps it is precisely because part of its motivation is involved with sexual attraction that this impulse to draw attention to the body finds an outlet among the civilized sophisticate equally with the untutored savage.

But whatever the final cause that induces mankind to adorn itself, the immediate reasons are often removed from sex and in some cases seem to have little or nothing to do with it. The caste mark on the



AN EXTREME in modern American sophistication is expressed by this black felt hat with blue feathers, designed by John Frederics and set off with jewels by Cartier



CONTRASTS in facial decoration. (*Top left*) A Tsimshian Indian with green face paint and copper appliqué ornaments representing the raven. (*Top right*) Charoti Indian, South America. (*Center*) Modern theatrical make-up, by Del Russo of Prince Matchabelli. (*Bottom left*) Arunta man of Australia, with face covered with feathers and blood as part of ceremonial ritual. (*Bottom right*) Mask-like effect of face paint in New Guinea employed on ceremonial occasions



TYPE OF HEADDRESS worn three centuries ago by the Indians of New York State and New England: Iroquois roached headdress of dyed deer hair, with face paint, crescent earrings, and bear-claw necklace

forehead of the Indian may indicate eligibility for marriage or the reverse, but it seems more likely that it simply represents a form of labeling quite common in various parts of the world and comparable to tribal markings and status costumes quite general in distribution. The headdresses and regalia of the New Guinea native, elaborate and spectacular as they are, are sometimes displayed only before members of the same sex or form part of a ritual involving tribal or group welfare.

Other markings, amulets, or ornaments are talismans for good luck. The tattooing of some tribes is associated with tribal life or may represent stages in the individual's progress through various age or ceremonial groups. A large number of examples may be cited of decorations that have become so traditional that a member of a group possessing one would feel awkward and outcast without it. Thus the human body becomes a medium for the display of symbol, for the support of ritual, for the expression of traditionalism. It is decorated or mutilated for sexual enhancement, it may be modified for hygienic reasons, and no doubt the psychoanalyst could find even the *id* lurking in some manifestations of this preoccupation with the body. Perhaps modern man's refusal to accept his beard is indicative of a deep-seated longing for his childhood and a reluctance to enter upon the maturity of which it is symbolic.



▲ BRIGHT FEATHERS and iridescent wings of beetles comprise this ear ornament from the Jivaro Indians of Ecuador



▲ EAR AND LIP ORNAMENTS as worn in the Faradje District of the Congo, Africa, illustrating the extensive piercing of lips and ears. The decorations along the edge of the ear are animal teeth

➤ A SILVER EARRING worn by the Yakuts of northeastern Siberia





◄ A TLINGIT INDIAN earring, probably a simulated shark's tooth, from southeastern Alaska



▲ A NECKLACE of shells from Samoa



▲ A LEATHER NECK AMULET, or grigri, from the Mossi District, French West Africa



◀ A BONE NECKLACE from the Fiji Islands, which exemplifies the elegance of simplicity



▲ DISCS of abalone shell decorate this red flannel dance hat of the Tlingit Indians, worn for any ceremonial occasion. The ear pendant was attached to the ear lobe or to a ring for festival occasions. The nose pendant is also mother-of-pearl



▲ A MARQUESAS CROWN. The shell and tortoise shell are true to the aboriginal style; the commercial buttons, introduced by early voyagers and whalers, replaced native decorative elements





▲ A QUILTED RED taffeta sun hat inspired by a Tibetan woman's sunshade in the American Museum's collection. By Sally Victor

◀ A MUSICIAN'S CAP, from Tibet



Courtesy of Abercrombie and Fitch

▲ POLAROID SUNGLASSES protect the eyes of the ultra-modern vacationer



▲ A SWAN'S-DOWN HEADDRESS decorated with eagle and magpie feathers, with a mask representing an eagle, worn by the Tlingit Indian medicine man in a dance to bring good fortune



➤ FOX-SKIN CAP with eyeshade of embroidered sealskin, from the Angmagssalik Eskimos of East Greenland



▲ PRIMITIVE BUT EFFECTIVE SNOW GOGGLES with a narrow open slit protect the Eskimo hunter from snow blindness

There are two principal methods of altering the body to improve upon nature. One is permanent, the other temporary. Each has its advantages and disadvantages. In the former are included tattooing, scarification, head deformation, piercing and enlargement of lips, nose and ears, foot-binding, tooth evulsion or filing, the amputation of fingers, and various deformations and mutilations of the sex organs. Designs or modifications of this kind need no refurbishing to retain their artificial form. The elegant designs that covered the Marquesans from head to foot in highly complex and delicate patterns and entranced the early voyagers would have been too laborious to apply for anything but rare and special occasions if they were impermanent. By tattooing them, however, a lengthy and painful series of operations furnished an individual with a superb and ineradicable decoration requiring no further attention but also admitting no

change. The flattened head of a Northwest Coast Indian might delight him as a mark of prestige, but it would permit no afterthought.

The temporary forms of bodily decoration embrace an enormous range and have the advantage of allowing for change. Body and face painting, ornaments, headdress, the vast array of jewelry, flowers, hats, clothing, and shoes can be put on or taken off according to the desire of their possessors. They require attention, and if valuable they represent wealth liable to loss or theft. They entail, as in the coiffure of Japanese or in the make-up of European and American women, tedious hours of grooming, but they allow for change and variety.



▲ INTRICATE DECORATIVE ELEMENTS fashioned of metal and kingfisher feathers adorn this bride's hat from China



▲ DOUBLE SPIRAL HAIRDRESS of a Bangba man on the Aruwimi River, in the Belgian Congo



▲ MANY of the fanciest decorative effects in primitive groups are evolved by the men. An unusual beard esteemed by a tribe in the Congo



▲ HAIR-DO EXTROADINAIRE: an Ababarambo woman of Mangalu Poko, in the Congo



▲ HAIRDRESS worn by the unmarried girls among the Hopi Indians of Arizona



▲ INSPIRED by a South American Indian feather headband in the American Museum's collections: a modern red felt skull cap with a brim of brown and white feathers. By Sally Victor



▲ A HEADBAND that on first glance might be either primitive or civilized. By John Frederics



▲ MODERN VERSION of the Plains Indian war bonnet. Originally worn only by warriors who had achieved distinction in battle, it has now been adopted by many tribes beyond the plains

To list the materials and objects that men and women have found decorative or useful in creating personal adornments would require a great deal of space. They include such classifications as stones, bones, ivory, teeth, feathers, furs, hair, grasses, flowers, plants, fibers, insects, animals, birds, fishes, metals, plastics, ceramics, wood, beans, seeds, and shells. And they range from simple objects used as they are to the results of the most complicated technologies. They represent the crudest forms of adaptation as well as the most elaborate esthetic developments, in some instances approaching the status of fine art.

All these adjuncts to and modifications of the human body are not necessarily meant to be esthetic, Many are, as I have already mentioned, either utilitarian or symbolic and ritualistic. But the creative spirit of man tends to endow even these with some aspect of decoration, or by their very nature they take on a decorative quality. This brings me to the necessity of stressing that the standards of what is beautiful are shifting and ephemeral. Those of us who find the adornments of uncivilized men barbaric, bizarre, or unlovely should remember that nothing appears more ludicrous, exaggerated, or exotic than our own styles of "only yesterday," when time has not yet rescued them from abandonment and refurbished them in the cycle of taste and fashion.

The photographs shown on these pages are drawn from a temporary exhibit in the American Museum, designed to illustrate the human fancy expressing itself on a part of the body—from the neck up. Even within this limited region the variety and ingenuity displayed is astonishing, but it represents only a fraction of the ways with which man has dealt with his body for purposes of adornment, symbol, distinction, prestige, utility, and sex. Apparently all men are brothers on the skin.



◀ A BLUE TURBAN with red tapestry trim, inspired by a Chinese turban from northern Yunnan. By Sally Victor

▼ HEADGEAR WORN by the principa wife of a Mayogo chief, in th northern Ituri District in equatoria Africa: a bristling circlet of dog' teeth, surmounted by a basketr cap adorned with feathers and bon hairpins





▲ BASKETRY HAT decorated with boar's tusks, worn by the Bontok Igorot warrior, Northern Luzon, Philippine Islands



▲ HEADGEAR worn by the Azandi, Niangara, Congo, Africa. Basketry base decorated with feathers



◄ FUR AND SILK HAT from Mongolia



► RATTAN HAT from the Ilokano tribe, Northern Luzon, Philippine Islands

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The Life History of the Monarch Butterfly

By LUCY W. CLAUSEN

THE LIFE HISTORY OF THE MONARCH BUTTERFLY

by Lucy W. Clausen

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Monarch butterflies in their natural habitat, showing all stages in the life history. Photographed from a group in the American Museum of Natural History.

AMNH photo

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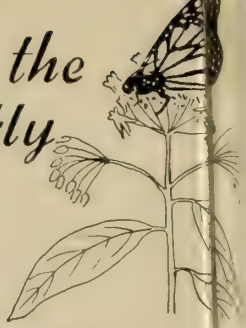
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The Life History of the Monarch Butterfly





By LUCY W. CLAUSEN

Introduction

Since all insects are not alike in their looks or in their habits, scientists have divided them into groups known as orders. Each group consists of insects with similar characteristics. Some orders include insects which are quite primitive. Other orders include insects which are highly complex and specialized. Within the twenty-seven commonly recognized orders of insects, the hundreds of thousands of species known today have been classified. Estimates of the total number vary from 500,000 to 750,000. Whatever the actual number, it is still true that there are more species of insects — many hundreds of times more — than all other species of animals put together. Nor is the end yet in sight. More than 10,000 new species are described every year.

One way the scientist is able to classify a new species of insect is by the kind of life history it goes through from egg to adult. Certain species show a primitive change in body form, or metamorphosis, in which the egg hatches into a nymph which closely resembles the adult. The higher orders have a complex metamorphosis in which the egg hatches into a larva; the larva feeds and grows and then goes into a pupal stage; from the pupa, the adult emerges as a free agent, capable of reproducing its kind.

The complex life history of the higher insects is as unique as it is intriguing, and its study is a constant source of interest and amazement to the uninitiated. The monarch butterfly affords an excellent example of this complex metamorphosis and as a familiar sight in city parks and in the open country, it is well enough known to most people to be of popular interest.

Stages in the Life History

Egg. The monarch butterfly (*Danaus plexippus*) starts life in a pale, greenish-amber egg. The female lays her eggs singly on the underside of milkweed leaves, and the eggs cling there like tiny droplets of moisture. Protected on the under surface of the leaf from the drying rays of the sun, yet warmed by them, the eggs develop and hatch into caterpillars in about a week.

Larva. The larva finds a ready source of food upon hatching. This is fortunate for the caterpillar because it has an enormous appetite and consumes great quantities of milkweed leaves. It spends most of its time eating, with the result that it grows and at the same time stores enough food to meet the rigid requirements of the non-eating pupal stage.

The caterpillar is brightly colored with alternate bands of white, black, and yellow the length of its smooth body. At each end, it has a pair of thread-like "horns" which serve as feeling organs as it moves about in search of food. The fact that it feeds almost entirely on milkweed leaves has earned it the common name of milkweed caterpillar.



Egg of the monarch butterfly on a leaf of the milkweed plant. Enlarged.
Photo by C. M. Grafton

The larval stage lasts one or two weeks. During that time, it grows too big for its skin and splits out of the old one and grows a new one. This molting occurs several times until the caterpillar attains a length of about two inches. Then it is ready for the chrysalis or pupal stage.

Chrysalis. Once it starts, the change from caterpillar or larva to chrysalis or pupa is completed in about a half hour. The larva shortens and thickens and soon becomes completely encased in a translucent green capsule with shining flecks of gold across its surface. Hence its poetic description as "the green house with the golden nails". This pupal case is formed inside of the last larval skin which then splits and slides back to reveal the new pupa.

Milkweed caterpillar feeding. *AMNH photo*





Milkweed caterpillar attached to a twig by the tail showing the beginning of the pupal case in the region of the head.

AMNH photos





The body of the caterpillar completely encased with the shed larval skin crumpled at the point of attachment.

Chrysalis nearly complete with segments visible through the translucent case.

The larva seeks the underside of a strong midrib of a leaf for this change. There it spins a silk thread from its mouth and by means of this thread, attaches its tail firmly to the leaf. The larva hangs downward and curves the head back slightly on the rest of its body so that it looks roughly like the letter "J".

Shortening and thickening begin in the head region and progress backwards towards the tail. They are accompanied by a rapid growth of the pupal case and a gradual disappearance of the bands of color. The insect is known at this stage as the prepupa since the loosened larval covering is being replaced by the pupa case.

The body of the larva is divided into fairly regular segments from head to tail similar to the body of an earthworm. During the change from larva to pupa, some of these segments fuse. Those which remain can be plainly seen through the pupal case, and a close scrutiny also reveals the breathing pores or spiracles. When the pupal covering is completed, the discarded skin remains crumpled near the point of attachment.

After it is completed, the pupal case, dangling by its black silken thread, gradually turns darker. To an observer, the pupa seems to be resting, but actually there is an amazing amount of activity going on inside. The insect is being completely remade. An immature feeding machine is being transformed into a free-ranging adult.

This regenerative process is poorly understood at present. No one seems to know the exact details of what happens in the chrysalis stage. However, when the process is completed, the new adult lies dormant and closely packed in the pupal case for a while, ready to respond at the proper time to unknown stimuli which cause it to break out, fully developed.

Adult. At the time the adult emerges, red and black markings of the wings can be seen through the pupal skin. This skin breaks open, and the butterfly laboriously draws itself out of its confined quarters and expands. The wings unfold rapidly. At first, they look like a crumpled paper bag, but in a short time they straighten out and attain their full size and form. Exposure to the sun and air cause them to harden and dry, and the butterfly is ready for its first flight.

Metamorphosis is complete. From a crawling caterpillar with short legs, chewing mouthparts, simple eyes, and practically no feelers or antennae, the insect has changed into an adult with long legs, sucking mouthparts, compound eyes, long sensitive antennae, and beautifully colored wings. It will grow no more.

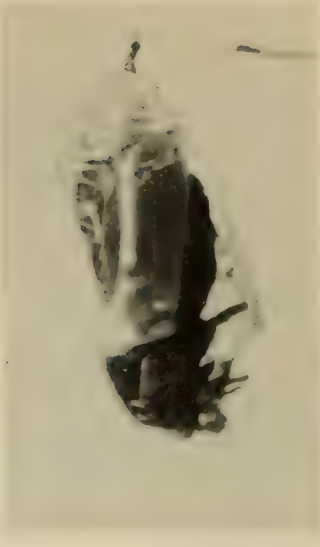
The color of the monarch's wings serve as one quick means of identification. This is true of many butterflies and is possible because the wing surface is large in proportion to the rest of the body and because the wings are permanently fixed in a non-

Chrysalis just prior to splitting open, with wing clearly visible under the case.
AMNH photo



Chrysalis case split up the side and adult just beginning to emerge.
AMNH photo





Left — Emergence of the adult Monarch struggling free of the split pupal case.
Below — Adult butterfly on a clover blossom after the wings have dried and hardened.
AMNH photo

folding form, in contrast for example, to the wings of a grasshopper which are folded when not in use. The general color of the milkweed or monarch butterfly's wings is a tawny red. The outer edges are black with white spots, and the veins are outlined in black. This coloration is due to tens of thousands of tiny colored scales which come off the wings in the form of a fine powder when rubbed. If the wings are denuded of their scales, a butterfly is hampered in flying. Because all butterflies



and moths possess scaly wings, they have been placed in the order Lepidoptera, from the Greek *lepido*, scale, and *pteron*, wing.

The first three or four days of the insect's adult life are spent feeding on the nectar of red clover, milkweed, butterfly weed, goldenrod, aster, thistle, and other favored plants in the vicinity. It is admirably equipped for securing the sweet fluid from these flowers. The butterfly has a tube or proboscis extending from its head when feeding. This tube can penetrate to the interior of a flower and suck up the nectar. When not in use, this proboscis lies coiled up like a watchspring under the head.

Flight

The monarch's vivid coloring makes it conspicuous in its natural surroundings, and yet it sails along in easy flight without any attempt to seek the safety afforded by the foliage of shrubs and trees. It is safe from one of the enemies of most other insects, the birds; they will not molest this butterfly because they find it disagreeable and distasteful as a source of food. The milkweed caterpillar is relatively safe for the same reason.

Normally, the monarch flies along at a speed of six or seven miles per hour anywhere from six to twelve inches above the flowers among which it seeks its food. When it is over barren ground, however, it increases its altitude to three or four feet



Drawing of the mouthparts of an adult butterfly in the resting or coiled position, with the large compound eyes showing above the coiled proboscis. *Photo by A. Howard, from a drawing by Alice Gray.*

and its speed to about fifteen miles per hour. If it is frightened, it will rise as high as two hundred feet in a great rush of wing action.

Long glides are frequent. The insect does not stay on an even keel when it glides but seesaws from side to side, putting first the left wings low, then the right wings. This results in a teetering forward movement and a general direction similar to the tacking of a sail boat. It is by means of the seesaw movement that the butterfly steers itself when it glides.

The monarch's flight is not confined to land areas alone. It also flies over water but at such a height that it is barely visible to the naked eye. Its speed over water has been estimated to be as high as twenty-five miles per hour. As soon as it gets over land again, it quickly descends and flies at its normal height and speed.

Most collectors are aware of the monarch's habit of playing "possum". When it is caught, it falls on its side and lies motionless as if dead. If uninjured and left unmolested for a short time, it rights itself and flies away quickly.

Mimicry

The monarch's distastefulness to birds has already been mentioned. This is its chief means of protection. The viceroy butterfly, *Basilarchia archippus,* on the other hand, makes a tasty morsel for birds, but because it closely resembles the monarch in appearance it is believed that birds do not distinguish between the two and hence do not eat either of them. The viceroy's imitation of the monarch's appearance is known as passive mimicry because the monarch does not actively cooperate in protecting the viceroy.

The viceroy can be distinguished from the monarch by the presence of a narrow black band across the hind wings and by its somewhat smaller size. In flight, the monarch makes slow deliberate flaps with its wings and glides with the wings held

at an angle. The viceroy makes quick flying strokes and holds its wings straight out from the body when it glides.

Migration

Many butterflies, including the monarch, are extensive travellers. The monarch, so common in the northern latitudes, flies south thousands of miles for the winter.

In the fall of the year, monarchs assemble in countless numbers along the northwestern coast of the United States. They cling to the leaves and branches of trees, and it is not uncommon to see bushes and branches actually bent with the weight of



The viceroy butterfly, right, compared with the monarch, left, indicating the viceroy's mimicry of the monarch's coloration.
Photo by A. Howard

hundreds of thickly massed butterflies at rest. As if by some pre-arranged signal, these clustered insects arise in a great cloud and disappear southward to spend the winter months in the Gulf States.

How they keep their direction over land and water, even in the face of strong winds and storms, is still a mystery. How they find their way over rivers, forests, swamps and cities, when none of the individuals in the swarm have ever made the flight

before; what their destination is once they leave the north; whether the same butterflies return north the following spring, or whether they are a new generation born during the winter; these are some of the questions about the monarch's migratory habits which science cannot answer at present.

References

COMSTOCK, J. H.

1933 An Introduction to Entomology. Ithaca, N. Y., The Comstock Publishing Co., 1044 pp.

DUNCAN, C. D., and PICKWELL, G.

1939 The World of Insects. New York, McGraw-Hill Book Co., 409 pp.

ESSIG, E. O.

1942 College Entomology. New York, The Macmillan Co., vii + 900 pp.

LUTZ, F. E.

1941 A Lot of Insects. New York, G. P. Putnam's Sons, 304 pp.

MATHESON, R.

1944 Entomology for Introductory Courses. Ithaca, N. Y., The Comstock Publishing Co., 600 pp.

TEALE, E. W.

1944 Grassroot Jungles. New York, Dodd Mead and Co., 240 pp.

Adult monarchs clustered just before migration. Photographed from an American Museum of Natural History habitat group.
AMNH photo



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